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THE VINCENNES-VILLE EVRARD COMPRESSED AIR TRAMWAY.

THE recent construction of the tramway line from Vincennes to Ville Evrard gives us an opportunity of making known the results obtained since the first experiments with Mr. Mekarski's compressed air engines. We must recall the fact that the Mekarski system consists in employing as a motive fluid not cold and dry compressed air, but a mixture of air and steam. We know, in fact, that when compressed air expands, it produces a strong depression of the temperature; the steam, in giving up its heat, limits such depression, which is the cause of a great loss of power.

Practically, with a determinate volume of highly compressed air we double the power that it is capable of producing upon a motive device by mixing it, at the moment of making it act upon the pistons, with a small proportion of steam.

On another hand, even if considerations of volume have led to compressing air to a high degree, it is advantageous to use it under a low pressure, and this is what has prompted the use of the regulator that completes the Mekarski process, in which there are interposed between the compressed air reservoirs and the engine (1) a heater that serves for obtaining the motive fluid and (2) a regulator or expander that serves for sending the gaseous mixture to the cylinders under a constant pressure, whatever be the pressure in the reservoirs. It is at Nantes, where the compressed air engines have been used exclusively for nearly nine years on tramways, that the advantages of the Mekarski system have been clearly shown. It appears from the results obtained, and from a comparison of them with those given by other modes of propulsion, that propulsion by compressed air is actually the most economical process. In fact, an examination of the figures of several years shows that while animal traction costs, according to the city and company, from 23 to 15 cents per mile, and steam propulsion in all its forms, with engines, with or without furnace, costs from 20 to 15 cents, propulsion by compressed air at Nantes is now costing less than 12 cents. Moreover, this result explains itself (despite the reduced performance of compressed air motors, due to the loss of power resulting from the interposition of the compressor between the boiler and motor) by the fact that the performance is largely compensated for by the very disadvantageous conditions under which steam is generated and used directly in small steam locomotives.

Now, the net cost of propulsion is one of the most important factors in the exploitation of tramway lines, for it alone represents more than half the expense of operating them, and it will therefore be understood how much influence the differences in this expense have on the financial result and the success of the enterprise.

It is such considerations, coupled with advantages that we shall have occasion to point out during the course of this article, that have caused the adoption of the Mekarski compressed air engines on the line running from Vincennes to Ville Evrard.

GENERAL ARRANGEMENTS.

This line, which is 58 miles in length, runs through the Bois de Vincennes, passes near Fontenay-sous-Bois, goes to Nogent-sur-Marne and Perreux, touches Neuilly-Plaisance, passes through Neuilly-sur-Marne, and finally ends at the departmental asylum of Ville Evrard. It is constructed partly with rails sunken in the streets and partly with surface rails on the driftways, and possesses gradients reaching half an inch to the foot.

An installation of propulsion by compressed air is divided into two distinct parts: (1) the fixed *materiel*—the apparatus in general for compressing the air, and storing and distributing it; (2) the rolling stock arranged for using the compressed air obtained from the charging works. The following considerations will show how the relative importance of the various elements of the installation has been determined.

As the works where the air is compressed are located at Maltournee, 39 miles from the end of the line at Vincennes, the cars have to be capable of making a trip of at least 8 miles without being recharged. Now as the expenditure of air on the cars is from 34 to 44 pounds per mile by reason of the undulating nature of the line, the supply necessary is 44 × 8 = 352 pounds, say, with a proper reserve, 370 pounds. The dimensions of the cars permit of storing under the seats nine reservoirs of a total capacity of 39 cubic feet.

As the number of starts per hour are one on week days and two on Sundays and fete days, the stationary apparatus has to be capable of furnishing in this time, inclusive of the service between Maltournee and Ville Evrard, 390 pounds of air. There have been provisionally installed two compressors that produce, together, 880 pounds of air, and which both operate on Sundays and fete days, but alternately on week days.

As soon as the service becomes more extended, a third machine will be necessary, so that there may always be one in reserve.

STATIONARY APPARATUS.

The depot comprises two steam generators each of 195 feet surface, 2 engines of 35 horse power, each of which actuates an air compressor, 12 accumulators capable of storing up the work of the engines in the interval between charges, apparatus for charging the cars, a repair shop, a room for charging and housing the cars, and a cottage with a sleeping room for the superintendent of the depot and officers for the administration.

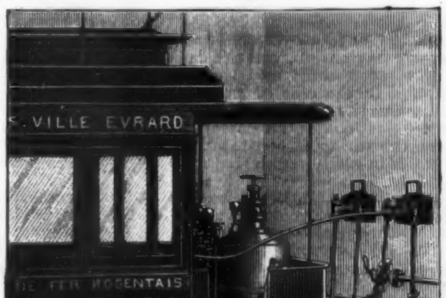


FIG. 2.—FRONT OF A CAR RUN BY COMPRESSED AIR.

The compressors (Fig. 1) are two-chambered, simple acting pumps that permit of reducing the elevation of temperature resulting from the compression, and consequently the motive work to be expended. The orifice of the suction valve of the first cylinder is provided with a cup into which flows a continuous stream of water. As the air enters the large cylinder it carries along this water, atomizes it therein, and is then forced into the second cylinder, whose dimensions correspond to the volume of air of the first.

In the pipe that connects the two cylinders there is a small reservoir which is in continuous communication with the non-working face of the small piston, and which keeps up a pressure of 75 pounds to the square inch.

Forced at a final pressure of 590 pounds into the small cylinder, the air enters the accumulators after passing through a reservoir in which it is freed from the water of injection.

As a whole, the charging apparatus consists of, 1, four distinct conduits that lead the compressed air coming directly from the compressors, the compressed air coming from the accumulators, the steam, and the hot water; 2, of charging orifices, each of which is provided with 2 two-way cocks, one of them giving passage to the air coming from the compressors or the accumulators, and the other to the hot water or the steam, as the case may be; and 3, of a *deverseur*, which the air maneuvers automatically, between chargings, in order to reach the accumulators.

ROLLING STOCK.

The rolling stock of the company consists, 1, of compressed air cars formed by the union, on the same truck, of the air reservoirs, the motor, and the compartment for passengers; and, 2, of small independent trucks.

The first present great advantages as regards running in the public streets, and, in the special case that concerns us, they were particularly indicated for ascending steep gradients under economical conditions.

The truck and car body constitute two parts independent of each other. The entire top of the truck is occupied by the body of the car, which is capable of holding 50 passengers—20 within, 6 on the platform, and 24 on the roof.

The effective space occupied by the apparatus and reserved for the conductor is only about an eighth of the entire length of the car. The weight of these vehicles is ten tons when empty. The supply of air is contained in nine reservoirs, 2 feet in diameter, made of 5 inch steel, and placed under the frame parallel with the axles and connected by copper pipes, so as to constitute two distinct receptacles—the one a battery of 71 cubic feet, and the other a reserve of 38 cubic feet. The object of the latter is to keep the air at a high pressure, thus permitting of giving, even at the end of a trip, a powerful stress that the battery would no longer be capable of furnishing.

The cylinders and motive parts are suspended laterally on the outside of the frame, and are protected by iron plate boxes closed by doors opening outwardly.

The heater contains 100 gallons of water at a temperature of 155°, and stands upright upon the small front platform. It is surmounted by the regulator. The conductor stands in front of the heater. On actuating the regulator, through a hand wheel, he regulates the pressure of admission, whatever be the pressure in the reservoirs. By means of a two-way distributing cock, placed upon the conduit coming from the regulator, he causes the air from the latter to act upon either the pistons or brakes. A simple maneuver, therefore, permits of changing abruptly from a full admission to a sudden arrest. The maneuvering apparatus are completed by a lever that changes the direction of the car's running and stops it. As the conductor has no fire to keep up, no boiler to feed, and no pressure to watch, his whole attention may be given to the proper governing of his motor. So it takes one man only to run the car.

The cars are charged every trip, that is to say, the air reservoirs are filled, and, at the same time, the temperature of the water is raised in the heater by an injection of steam. In order to effect these operations, the cars are placed opposite the charging orifices (Fig. 2), and the heaters are put in communication with the generators, and the reservoirs with the accumulators, by means of coupling pipes. In this way a pressure of 400 lb. to the square inch is obtained, and this is raised to 590 lb. by putting the reservoirs in direct communication with the pumps. The automatic regulator on the conduit leading the air from the pumps to the cocks does not allow the air in the reservoirs to reach a pressure of more than 590 lb. Beyond this limit, the air is turned into the accumulators. It takes about fifteen minutes to effect the charging.

After nine years' operation at Nantes, the satisfactory results obtained on the tramway line under consideration, which presents great difficulties as regards traction, seem to indicate that the system of propulsion by compressed air is, up to the present, the best and most economical one, and the one that best answers all the conditions necessary for running in the public streets; in a word, the best of the methods of propulsion used upon tramways.—*La Nature.*

FIG. 1.—APPARATUS FOR COMPRESSING AIR.

IT may not be known to some what causes the different colors in bricks. The red color of bricks is due to the iron contained in the clay. In the process of burning, the iron compounds are changed from the ferrous to the ferric condition and rendered anhydrous, thus developing the color.

MODERN IMPROVEMENTS IN THE STEAM ENGINE.*

By SCOTT A. SMITH.

THE steam engine, as completed by James Watt in the years 1765 to 1784, contained nearly all the essential principles for a perfect machine.

His inventions included, 1, use of steam above the piston to make the engine double acting, 2, the condenser, 3, the fly ball governor with the throttle valve, 4, the indicator, to show the action of the steam in the cylinder and from which the power could be computed, 5, the steam gauge, 6, barometer gauge, 7, a counter to register the speed or strokes of the engine, 8, the parallel motion.

His comprehensive mind first developed the principle of using steam expansively, and included the far-seeing idea that the steam cylinder must be kept hot by the use of a steam jacket and the additional use of an air space and non-conducting substances.

In 1781 Jonathan Hornblower patented his double cylinder, or what is now known as a compound engine. In 1804, Authur Woolf introduced his modification of the same compounding principle, that is, to use the steam first in one cylinder and then in the second—the first non-condensing, the second condensing.

Watt's engines used 6 to 8 lb. of coal per hour per horse power, when working steam expansively with 7 lb. initial pressure with 202 feet of piston speed per minute, as per his rule. It is stated that Woolf reduced the cost of a horse power to 4 lb. of coal per hour.

No one having the inventive type of mind possessed by James Watt took up the subject of the improvement of the steam engine until about the year 1846, when George H. Corliss, then working to complete a machine for sewing harness leather, at the works of Bancroft, Nightingale & Company, was induced by them to give his attention to forwarding their interests in the manufacture of steam engines. He, with an intuitive faculty, seized on and developed certain broad and comprehensive principles for governing the induction and eduction of steam in steam cylinders.

Before his inventions were made, Maudsley in England had operated a single supplemental valve by the fly ball regulator, which latter raised or lowered a rotated cam graded to retain the valve open a greater or less period. In Paris, about the time of Mr. Corliss' invention, an engine had been built in which separate induction valves, one for each end of the cylinder, had been operated in a similar way. In our own country, in 1841, F. E. Sickels invented the drop cut-off, using what is known as the poppet valve, a form now used by two well-known builders of mill engines.

Had all of these inventions lain under Mr. Corliss' eyes, they would have constituted as much a hinderance as an aid in developing his unique invention.

It would not interest you to give a detailed description of Mr. Corliss' engine, which is so well known to you; but I wish to impress this upon your minds: that in carrying out any principle, or invention, in mechanics, it is comparatively easy to arrive at a desired result by complicated mechanisms, one part to help another, but simplicity when combined with efficiency is very difficult of attainment, and, too, to so dispose the parts that they are plainly accessible for examination, adjustment, or repairs. The fact that his complete type of engine has been adopted by engine builders all over the world puts upon it a universal stamp of approval.

His inventions were evolved from a mind capable of clearly seeing all sides of a subject, and equal to the task of originating and executing, backed by tireless endeavor. Added to this was an ability to formulate plans for placing his engines in successful use in the varied industries of the country, thus calling for engineering ability on his part of the highest type. His various engines are typical of daring conceptions and successful execution.

The three things in steam engineering which now engross much thought are steam jacketing, compounding, and high piston speed, all three quite inseparably connected. As before stated, steam jacketing and compounding date from about the year 1800. The great advance in the mechanical arts enables us to construct engines to run with certainty and smoothness at high piston speed, up to say 800 feet per minute; also we are now able to build boilers capable of carrying steam pressures approaching 200 lb. or even more. Thus these conditions of high steam and high piston speed open the way for compound engines, which have already very largely driven the older forms of marine engines out of use, and now even the locomotive has its third cylinder for using the exhaust steam from the first two.

Careful tests of three condensing engines at the Cincinnati exhibition, in 1870, showed that only 71-100 of the steam entering the cylinders was made available as shown by the indicated power. These were simple condensing engines with the cylinders properly clothed against radiation. They gave an indicated horse power with 1·94 lb. of coal per hour, on a basis of 10 lb. of water evaporated with one pound of coal.

Steam Jacketing.—When steam, for instance, of 100 lb. pressure, enters a steam cylinder, the temperature falls. Thus a portion of the steam is converted into water, which is held either in suspension, as wet steam, or falls as free water, having, however, nearly the temperature of the steam in the cylinder. Hence it is necessary to keep the temperature of a steam cylinder as near as possible to that in the boiler, in order to limit this reconversion of steam into water.

Compounding, or the use of two or more cylinders, allows, 1, the use of high initial steam in the first cylinder, of small diameter, 2, the most efficient use of high grades of expansions, because the temperature of each cylinder may be kept at a nearer point to that of the incoming steam than can possibly be effected in a single cylinder. High speed diminishes the time in which condensation can take effect.

The first very successful use of compounding with accompanying steam jacketing, in this country, was in the Lynn pumping engines designed by E. D. Leavitt, Jr. These engines have cylinders 18 in. and 36 in. by 7 foot stroke, 18 7-10 revolutions, 80 lb. of steam and 14 expansions. Piston speed, 261·8. It is stated that they give a duty of 100 million gallons, as compared with 60 millions, the best previous duty, for each 100 lb. of coal. They were first put to use January 15, 1873. Mr. Leavitt, as engineer for the Calumet and Hecla Copper Mining Company, has put in operation a compound engine of 4,700 horse power, working with initial steam pressure of 135 lb., using 6 expansions at a piston speed of 720 feet per minute. Stated duty, 1⅛ lb. of coal per hour per I. H. P.

He is now having built three triple-expansion engines of 2,200 H. P., each to work with a boiler pressure of 185 lb., and 16 expansions. His expectation is to get an I. H. P. with 1 1-8 lb. of coal, charging all coal put upon the grates. These engines are of course steam-jacketed, and also the steam is reheated between the cylinders by steam from the boilers.

The success of the pumping engines at Pawtucket and at the Petaconsett station, and also the high duty given by the compound engine at the Nourse mill in Woonsocket, all built by Mr. Corliss, fully establish with Mr. Leavitt's engines the practical success of compounding.*

I present to you a pamphlet by Mr. Leavitt on pumping machinery, and you will see that he unhesitatingly pays Mr. Corliss very high tribute for his success at Pawtucket and Petaconsett. I also give you a framed blue print of Mr. Leavitt's compound engine Superior, of 4,700 horse power, before referred to, showing his peculiar valve gear and regulator combined.

An advantage to be mentioned for mill use with the compound engine is that a portion of the exhaust steam from the first cylinder may be used for heating and other purposes.

It is quite legitimate to say that in steam-jacketed cylinders many difficulties have been met with in construction, difficulties of so serious a nature that, were the advantages not apparent ones, the method would certainly be abandoned.

Also it is very pertinent to the question of the use of two, three, or four cylinders to say that the exigencies of steam navigation, viz., the desire for equable motion on the screw shaft and the existence of a constant load, and in the case of pumping engines a constant load, make the use of compounding best available for them. Next comes the cotton mill, or other industry, where the power is constant. A greater or less difficulty lies in easily regulating at least beyond a second cylinder.

Steam Engine Construction.—There is still something to be learned, or decided on, in this direction, particularly with respect to some details, as, for instance, the way to make a crank pin so that it shall not break; the best method for fastening a piston to its rod, and the rod to the crosshead; the best construction of crosshead, and so on to the crank pin. When you have your next annual meeting of the National Association of Steam Engineers, I hope you will take up this subject and discuss it broadly.

I can tell you with a conviction born of experience that you want in your engines neither a steel shaft crank, crank pin, connecting rod, crosshead, nor piston rod. The best hammered iron is more reliable under the conditions of steam engine use.

Here is a fact of much significance to all parties interested. One make of drop cut-off engine of say 100 horse power weighs 9,000, a second 18,000, a third 24,600 lb., all having the same sized cylinders as to diameter and length of stroke; the weights of the fly wheels being omitted.

To purchasers of steam engines I would say, through you, that they should insist that some method of construction shall be adopted by builders of steam engines so that when by accident water is taken into the cylinder in large quantity, a means of relief shall be provided. Such a provision has already been made by one firm by leaving an opening in the cylinder head, then covering the opening with a plate held by bolts which will give way under a pressure somewhat exceeding the regular pressure of the steam. I am told by Mr. Leavitt that his steam stamps for ore crushing are provided with this invention. There is a double meaning in my suggestion, for as the case now stands, if any part of an engine breaks, with a greater or less "smash-up," then the stereotyped cry comes from the builder of the engine, "You had water in the cylinder." It is a much more difficult thing to prove that you did not have water in the cylinder than it is to simply assert that water there caused the damage.

I am firmly of the belief that, in view of the present high piston speed of engines, and the inevitable further advance in that direction, two eccentrics will come into general use on all four-valve engines worked by the wrist plate motion, in order to obtain a suitable amount of compression, amounting to say one-third or less of the initial pressure. I unhesitatingly assert that he who says that there is no benefit from this cushioning at the end of the stroke is either blind or else will not see.

As the steam jacket, invented by James Watt, a century since, has lain quite dormant until near the present time, and as the principle of compounding, also one hundred years old, has shared the same fate, thus depriving American manufacturers of benefits which are to-day clearly recognized, it seems very legitimate to agitate engineering waters, and thus bring other things to the surface.

In conclusion, and to leave upon your minds pleasant thoughts other than the dry details of steam engines, I will tell you something of the great and good man James Watt, one whose memory should be ever fresh in our minds to impel us to walk in his ways, in so far as God has given us the power to do it.

Watt died at Heathfield, in Staffordshire, August 25, 1819.

His friend Lord Jeffrey said of him: "Independently of his great attainments in mechanics, Mr. Watt was an extraordinary and in many respects a wonderful man. Perhaps no individual in his age possessed so much and such varied and exact information, had read so much, or remembered what he had read so accurately and well. He had infinite quickness of apprehension, a prodigious memory, and a certain rectifying and methodizing power of understanding, which extracted something out of all that was presented to it. His stores of miscellaneous knowledge were immense, and yet less astonishing than the command he had at all times over them. It seemed as if every subject that was casually started in conversation with him had been that which he had been last occupied in studying and exhausting; such was the copiousness, the precision, and the admirable clearness of the information which he had poured out upon it without effort or hesitation. Nor was this promptitude and compass of knowledge confined in any degree to studies connected with his ordinary pursuits. No man could be more social, less assuming or fastidious in his manners, or more kind and indulgent to all who approached him. He had a certain quiet and grave humor, which ran through most of his conversation, and a vein of temperate jocularity, which gave infinite zest and effect to his conversations."

Sir Walter Scott said, among other things, that "he was not only the most profound man of science, the most successful combiner of powers, but one of the best and kindest of human beings."

A statue of Watt stands in the parish church at Handsworth, another is in the college at Glasgow, one at Greenock, and lastly a colossal one is in Westminster Abbey, bearing an inscription from the pen of Lord Brougham.

* Lecture before the R. I. Engineers' Association, Feb. 18, 1888.

* In compounding, or in the further use of a third or fourth cylinder, for mill engines, with steam on the boilers increasing from 100 pounds per square inch for compounds to 225 pounds for quadruple cylinders, the expansions may be carried up, say, from fourteen to thirty times. S.

THE DEVELOPMENT OF BRIDGE CONSTRUCTION, WITH NOTICES OF SOME REMARKABLE HISTORIC BRIDGES.

By Prof. W. P. TROWBRIDGE.

IN works of engineering generally, unlike those connected with the fine arts, there is little to be learned from the ancients. We are surrounded on all sides by structures of a purely engineering character, which could only have been devised and executed in modern times, and for which antique models do not exist. There are certain elements, however, of these structures which belong to all ages, since they are but the practical applications of simple mechanical laws in which boldness of conception and design, simplicity and taste in construction, and perfect adaptability to their uses and objects, exhibit the intellectual condition of the people by whom such structures have been erected.

It may be said that properly constructed lines of land travel are both causes and effects of civilization. The common road and the railway, pushing out beyond the boundaries of populous districts or penetrating uninhabited wildernesses, are sure to be followed by an advancing tide of emigration, while the introduction and maintenance of thoroughfares more complete and permanent in their construction than was at first practicable is an indication of increasing thrift, culture, and refinement on the part of the people.

The famous engineer Telford, who constructed many hundred miles of good turnpike roads in England and Scotland under special acts of Parliament, expressed the opinion or belief that these roads had advanced the communities of the districts through which they passed one hundred years in civilization.

The construction of a line of land travel involves, of course, numerous bridges, rude and cheap in primitive times, but exhibiting elements of a more permanent character and more pleasing architectural features as a country advances in wealth and education. There are few architectural structures which more truly indicate intellectual cultivation and general prosperity than the bridges found along the lines of intercommunication.

It is certainly true in our own day that a district in which streams are crossed only by fording is either sparsely populated or else occupied by ignorant, unthrifty, and improvident communities. The energy, the talent, the means of surmounting material obstacles, are in such cases wholly or partially wanting; while, on the other hand, where wealth is accumulated and science and the arts are fostered, the bridge, in beauty of design and workmanship, is often the most significant expression, not only of the skill and genius of a people, but of their refinement and taste.

It is unfortunate in this latter respect that the necessities of railway traffic in modern times have caused the introduction of forms and modes of construction in iron, scattered everywhere throughout civilized countries, which mar the most delightful landscapes, and which contain no lines of grace perceptible to any one except the engineer, who may claim to find beauty in every structure which fulfills its object. He only knows how much of intellectual labor the uncouth skeletons which carry our railway trains safely across the widest chasms have cost in the efforts that have been required to design and adapt them to their uses.

An English writer on the subject of bridges in discussing, forty years ago, the designs of American timber bridges, although compelled to give them the preeminence, applied to them the remarkable criticism (because they were boxed in or covered on the sides and top to preserve them from decay) that they "looked like coffins for sea serpents."

If this curious criticism be in any way applicable, it might be said now that the coffin has been removed and the skeleton, transmuted into iron, exposed fully to view.

It would appear to be not only difficult, but, in the eyes of many, a violation of constructive art, to attempt to give the same pleasing appearances to most modern systems of iron bridges that are easily and naturally embodied in bridges of stone; and although the present is the age of iron, yet it is to be hoped that the stone bridge, once the pride of the great engineers of history, may not be given up and forgotten, but that it may be reintroduced, whenever circumstances may allow, in order that it may again add beauty to our landscapes, even in rural districts and outside of the limits of ornamented parks and pleasure grounds, to which it has in modern times been mostly confined.

It should not, however, I think, be considered impossible to add to the skeleton structures in wrought iron, which are now met with at every turn, and which are constantly being multiplied, simple architectural adjuncts to relieve their uncouth appearances. In one instance, at least, this has been done in this country with marked effect, though the conditions under which the structure was built were certainly unusually favorable in this respect. I allude to the Girard Avenue bridge in Philadelphia, designed and built by the Phœnix Bridge Company, a wrought iron bridge, which has called forth from many a traveler from foreign lands expressions of delight on account of the architectural elegance of its design.

The history of the development of the art of bridge construction is marked, to a certain extent, by periods or eras coincident either with the introduction of new materials in the arts or with the necessities which

have arisen for compassing greater spans under conditions of heavier traffic. The suspension bridge, of very ancient origin, has held its place, though to a limited extent, until our own time, when its place is likely to be usurped, to a great degree, by the cantilever. Built in primitive times with cables of organic material, the introduction of wrought iron and of iron wire furnished facilities of construction and elements of durability and strength which the older suspension bridges did not possess, and the great bridge between this city and Brooklyn may be regarded as the culmination of this system, and perhaps the most remarkable example which the world is destined to see; there being inherent defects of the system, which render it inapplicable to rapidly moving heavy loads, which will always be a sort of bar to its general use.

The reverse of the suspension bridge, the arch, of all systems has held the most universal sway, until the long spans met with in the routes of railway communication, and the difficulties of establishing numerous piers in swift currents and on treacherous foundations, brought about, first, the long span timber bridge, and subsequently the modern structures in wrought iron, which have become so common in our times. The history of the arch in bridge construction extends from a period further back than the beginning of the Christian era to the present day; but the days when great engineers like Perronet, Nimmo, Telford, Rennie, and others, could acquire fame by building chaste and beautiful arch bridges of stone masonry seem, unfortunately, to have passed.

One of the largest and most picturesque structures of this kind in the world, unsurpassed in many respects by the most famous arches of history, constitutes a part of the Potomac aqueduct, near the city of Washington. This magnificent structure, called the Cabin John bridge, erected by General M. C. Meigs, of the U. S. Army, will probably remain the most conspicuous memorial in this country of a system which, for highways and railways, is gradually being replaced by iron.

Cast iron arch bridges were first introduced a little over one hundred years ago in England, and for a time met with marked public favor. The facility with which cast iron lends itself to the introduction of minor decorations in forms and mouldings enabled bridge architects to present a great variety of pleasing designs, and numerous bridges were constructed about the beginning of this century which attracted much attention. It has been claimed that Thomas Paine, whose name has been preserved in history only through his atheistical writings and doctrines, was the inventor of the cast iron arch bridge. This claim is, however, not well founded, inasmuch as this kind of bridge was already in use in England before Paine sailed from America with the object of carrying his plans abroad, where he thought they might be favorably considered.

The cast iron bridge had, however, but a brief historical record. The want of sufficient elasticity, the imperfection of castings, and the liability to rupture under certain strains or blows, have caused cast iron to be thrown out of the catalogue of available materials for the principal elements of bridges of any considerable importance.

Of timber bridges it may also be said that they have had their day and have fulfilled their temporary uses. When railways were first introduced, about the end of the first quarter of the present century, the necessity of providing bridges along their routes, of longer span and cheaper construction than could be furnished in stone, led to a more critical study in the use of timber for bridges than had ever before been bestowed on the subject. Previous to this, however, many noted bridges had been built, which were masterpieces of work in timber, and which have preserved to history a few names which will always be remembered in connection with the noble art of carpentry—an art now, for various reasons, in its decline. Among these names that of Ulric Grubenmann, who built the famous bridge over the Rhine at Schaffhausen toward the end of the last century, and the name of Timothy Palmer, of Newburyport, Mass., will always be prominent. The timber highway bridges of the latter in this country were models of scientific, practical, and mechanical workmanship. The Schaffhausen bridge stood alone as a great work in which the inherent principle of construction was the arch combined with the elements of the common roof, but it brought into use no new principle, and had no elements which might cause it to be reproduced or copied.

Another name destined to a more substantial and enduring fame in connection with timber bridges is that of Ithiel Towne, for many years before his death an architect of New Haven, Conn. Two or three miles out from New Haven there is a covered bridge spanning a narrow part of Lake Whitney, which, in connection with the subject which we are discussing, has an interesting history. This bridge, which is called the Towne lattice bridge, although presenting in itself no artistic feature, being entirely covered in, and being, in fact, the first of the bridges which on this account was sneered at, by the eminent English writer referred to, as looking like "a coffin for a sea-serpent," is nevertheless the central feature of a limited but charming little landscape, and to the people of New Haven who know its history is the chief object of interest in this particular spot. Few persons, however, are aware of the fact that the mechanical design of this bridge was the first departure from the principle of the arch and the suspension principle ever attempted; and that it is, although constructed entirely of timber, without a nail or a spike except those used in the board covering, the prototype of nearly all modern constructions in iron which have of late years become so numerous, and which are classified as braced girders. This bridge was devised and erected by Ithiel Towne, about the year 1823, for the New Haven and Hartford Turnpike Company, across the Mill River. It is 100 feet long, fourteen feet wide, and twelve feet high, and is built on the principle of straight top and bottom chords, connected by diagonal bracing; a principle invented by Mr. Towne and never before introduced into bridge construction.

About the year 1840, Mr. Eli Whitney, of New Haven, who was then constructing the dam and reservoir on Mill River, which now supplies New Haven with water, removed this bridge bodily on skids from the point where it was first erected to the place it now occupies, about half a mile distant—a difficult feat of engineering, but accomplished without removing or displacing a single timber of the bridge. The bridge is thus probably the oldest timber bridge of any considerable span in this or any other country, having fortunately escaped the fate of nearly all large timber bridges—destruction by fire.

The principal parts have never been renewed, and, thanks to the board covering, these parts are still sound and serviceable.

I have dwelt at some length on the history of this particular bridge, because the interesting feature of its construction was the employment of an entirely new principle in bridge construction which, by mere change from timber to wrought iron and steel, has been followed ever since. Details have changed, the modifications giving rise to various types as they are known at the present day, but the fundamental principle has been almost universally adopted in all countries, and remains unaltered.

The tubular bridge, a later design, of which the famous Menai bridge, erected by Stevenson and Fairbairn across the Menai Straits, is the most conspicuous example, has had no important development, skeleton structures being now universally preferred.

The latest advance in what some would prefer to call the "evolution" of the bridge is the cantilever system. Though designs were made, and the system strongly urged upon the engineering profession of this country nearly twenty years ago, for spans exceeding the possible limits of the straight girder, yet it was not until Mr. C. C. Schneider designed, and the Central Bridge Works, of Buffalo, constructed, under his supervision, the Niagara cantilever bridge, that the merits of this system for very long spans became fully appreciated.

The system has spread with great rapidity since the Niagara cantilever bridge was completed, the Forth bridge, now being erected in Scotland on this principle and destined for railway traffic, having the extraordinary span of seventeen hundred feet—a greater length than that of the New York suspension bridge.

A cursory glance at the development of the art of bridge construction thus reveals a series of interesting facts:

First—That masonry arch bridges, from their simplicity, elegance, permanence, and strength, have in all ages been the most favored forms of construction for highways, and that the use of iron and steel has in no way changed this popular favor, except where the employment of these materials is either favorable to economy or to the introduction of larger spans. For railway bridges, other considerations favor also the use of iron and steel over the use of stone.

Second—The introduction of cast iron arches, though favorable to architectural elegance of design, has not resulted in any permanent useful developments.

Third—Timber bridges have in all ages been regarded as temporary structures which were to be replaced sooner or later by others more permanent in character.

Fourth—The springing up and immense development of the railway systems of the world within the last sixty years, and the concurrent progress made in the metallurgy of iron and steel, have given rise to entirely new problems in bridge building and to a new branch of the engineering profession.

Fifth—The demands of railway traffic for direct lines which must surmount every obstacle either by tunnels or bridges, the heavy weights transported, and the great speed of trains required, have diverted, for a time, public interest from the highway—formerly, in the time of the old stage coach, the source of many peculiar delights to the traveler.

We are now rattled over bridges and whirled through tunnels at a speed which precludes more than an unsatisfactory glimpse of the scenery which seems to flit by us; comfort, safety, and speed fill the measure of our expectations. But the change has caused our highways to be neglected, and even in the great thoroughfares which lead out from our cities and towns the iron bridge seems to have driven out the more beautiful and durable structures in stone, which ought here, at least, to occupy their proper places. There is no internal improvement more imperatively demanded in this country at the present time than systematic reconstruction and maintenance of our highways.

Viewed as intellectual and mechanical achievements, however, the great bridges of modern times are to be classed with steamships, locomotives, and pumping engines, which could not have been suggested a hundred years ago by the most vivid imagination. They are triumphs of science rather than of art, and as such we should, perhaps, be content to look at them; deriving our interest from cold, unimpassioned reflections upon the thought, the genius, and the skill which have produced them, rather than from any such pleasing emotions as arise when we look upon some of the works of the same kind of the older bridge architects.

FAMOUS BRIDGES.

The most ancient bridges of which we have any precise knowledge were built by the Romans, all those of a permanent character having been arched masonry bridges. It is certain, however, that such bridges were built in China many centuries ago, but of their history little is definitely known.

Of the Roman bridges, that erected by Trajan across the Danube is said to have been the most magnificent. It consisted of nineteen arches, each 170 feet span, the piers rising 120 feet above the foundations. The width of the bridge was 60 feet, and its total length 1,500 feet. This bridge was destroyed by the immediate successor of Trajan, Hadrian, for fear that it might afford an easy passage for the barbarians into the empire. Some of the piers are still to be seen, however, near the town of Walkel, Hungary.

The next considerable work of this kind built by the Romans is the Pont du Garde, which is still standing.

It served the double purpose of a highway bridge over the Gardon and an aqueduct for supplying with water the town of Nismes, in the south of France. The bridge is a triple arcade, the lower tier of arches having a total length of 660 feet, and supporting a second tier of eleven arches of 780 feet, and on these is supported a third tier 850 feet in length. This brings the structure up to the level of the aqueduct, which rests on the third tier of arches. This extraordinary structure is built of very large stones put together without cement and held together by iron clamps. The whole height is 190 feet above the river.

Another Roman bridge, over the Tajo at Valenza, about 25 miles from Madrid, 679 feet in length, and consisting of only six arches, was built at the time of Trajan. It is now standing, but not used.

A single arch near the old town of Brionde, in France, having a span of 181 feet, and which is said to be still standing, is attributed to the Romans.

Another bridge, 2,400 feet in length, near Lyons, in the south of France, was also erected by the Romans.

Among the later Roman arched bridges may be mentioned the Devil's bridge over the Serchio, Italy, which is, in some respects, the most remarkable in the whole history of stone bridges, being only twelve feet wide between the parapets, and spanning a stream in which the floods rise sometimes nearly to the crowns of the arches, and yet, while every other structure on the turbulent Serchio has been swept away, this bridge has withstood the floods of nearly nine centuries.

The bridge of Trezzo, built in 1380 by Bernabo Visconti, Duke of Milan, consisted of a single arch of granite of 251 feet span, the largest stone arch probably ever erected. It was destroyed by Carmagnola 120 years after its erection.

The aqueduct bridge of Alcantara, near Lisbon, begun 1713 and finished in 1732, consists of thirty-five arches of various dimensions, the largest having a span of 108 feet.

The bridge of Neuilly, which crosses the Seine, built between the years 1768 and 1780 by the famous Perronet, is considered one of the most beautiful of existing bridges. It consists of five equal arches of 128 feet span each, each arch being composed of eleven arcs of circles of different diameters, the resulting effect being a curve in appearance like an ellipse, but even more pleasing to the eye than an ellipse.

In England the oldest bridge remaining entire is the bridge of Croyland, in Lincolnshire. It was erected about the year 860.

The first bridge over the Thames was of wood, built in the reign of Ethelred II., about the year 1000.

The Old London bridge was begun in 1176, under Henry II., and finished in 1209. The length was 940 feet, the height 44 feet, and the width between the parapets 47 feet. It was hardly much more than a wall of stone thrown across the river, a few openings being left for the passage of the waters of the Thames, half the waterway being taken up by the piers. It was extensively repaired and altered five hundred years after its erection, and in 1823, the obstruction which it offered to traffic on the river having become the subject of persistent and loud complaints, this bridge was removed and the New London bridge erected in its place by Mr. John Rennie. The new bridge was placed near the site of the old bridge, and is formed of five semi-elliptical arches, the least of which is larger than any elliptical arch ever before erected.

The Westminster bridge over the Thames was constructed by a Swiss engineer, Mr. Labalye. It is 1,220 feet long, and consists of thirteen large and two small arches. It was opened to the public in 1750.

Blackfriars bridge, also one of the London bridges, was built by Mr. L. Mylne, between the years 1760 and 1771. It is 999 feet long and consists of nine elliptical arches.

The Waterloo bridge across the Thames, nearly midway between the Westminster and the Blackfriars bridges, is, perhaps, the most magnificent structure of its kind in Europe. It was built by Mr. Rennie, and is composed of nine elliptical arches, each having a span of 120 feet. Its length is 1,380 feet.

The first cast iron arched bridge was built across the river Severn at Colebrookdale, England, by Mr. Darby, in 1779. Some years later Thomas Paine made preparations for erecting a similar bridge at the same place, according to plans which he had prepared in this country, and caused his bridge to be erected for exhibition in a meadow near Colebrookdale; but having no funds to erect the bridge across the Severn, it was removed from the meadow and parts of it used for a bridge over the Wear in 1793.

Vauxhall and Southwark bridges over the Thames were of cast iron. The latter, built by Mr. Rennie, was composed of three cast iron circular arches, the central arch having a span of 250 feet. Ten years were occupied in its construction.

Iron suspension bridges were constructed in Europe as early as 1615, but this class of bridges had already existed in Asia, Africa, and America at much older dates. The Spaniards found a suspension bridge in Peru, built by the fifth Inca, the cables, four in number, being composed of vegetable fiber, and the floor made of rushes. This bridge was systematically repaired every six months and remained standing and in use up to a very recent date.

Telford constructed a suspension bridge across the Menai Straits, of 560 feet span, which at the time was regarded as a great achievement. All suspension bridges of the old world are, however, insignificant in comparison with the great bridge, beautiful in design and appearance, as well as magnificent in its proportions, erected by Mr. Roebling across the East River between New York and Brooklyn.

In timber bridges, America has taken the lead of all other countries, the only structure in Europe comparable with the great timber bridges built in this country during the early part of this century being the Schaffhausen and Wittengen bridges across the Rhine, built by Ulric Grubenmann. A stone bridge that had spanned the Rhine at Schaffhausen having fallen, a model of a wooden bridge to supply its place was presented by Grubenmann, and accepted. This extraordinary work was completed in 1758. The length of each span was 364 feet. It was destroyed by the French in 1799.

Another famous bridge of timber, called the Colossus of Fairmount, was erected over the Schuylkill, at Philadelphia, by Louis Wernwag, toward the close of the last century. It had the form of a very flat arch, having a span of 340 feet. Its slender, graceful appearance was much admired. Fannie Kemble, in her journal, compared it to a "scarf rounded by the wind and flung across the river." It was destroyed by fire in 1838.

Timothy Palmer, of Newburyport, Mass., built several notable bridges, one of which crossed the Schuylkill at Philadelphia. The construction was a combination of king posts and bracing with the arch. Another was built across the Piscataqua River, about seven miles above Portsmouth. Both these bridges received extended notices in both American and foreign journals.

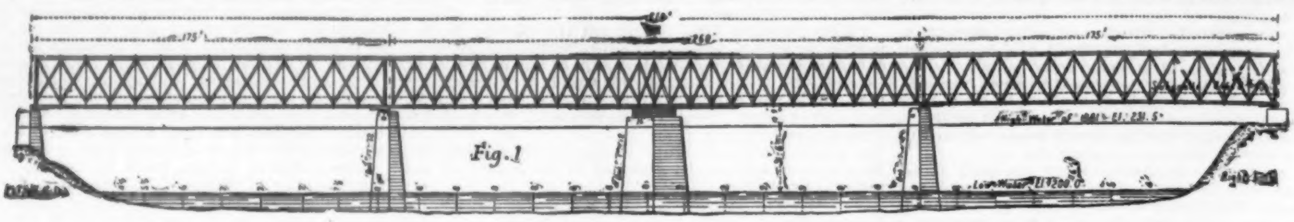
Among the architects of notable timber bridges during the early part of the century appear the names of Burr, Towne, Long, and Howe—Long and Howe having followed Towne, and produced modifications of his

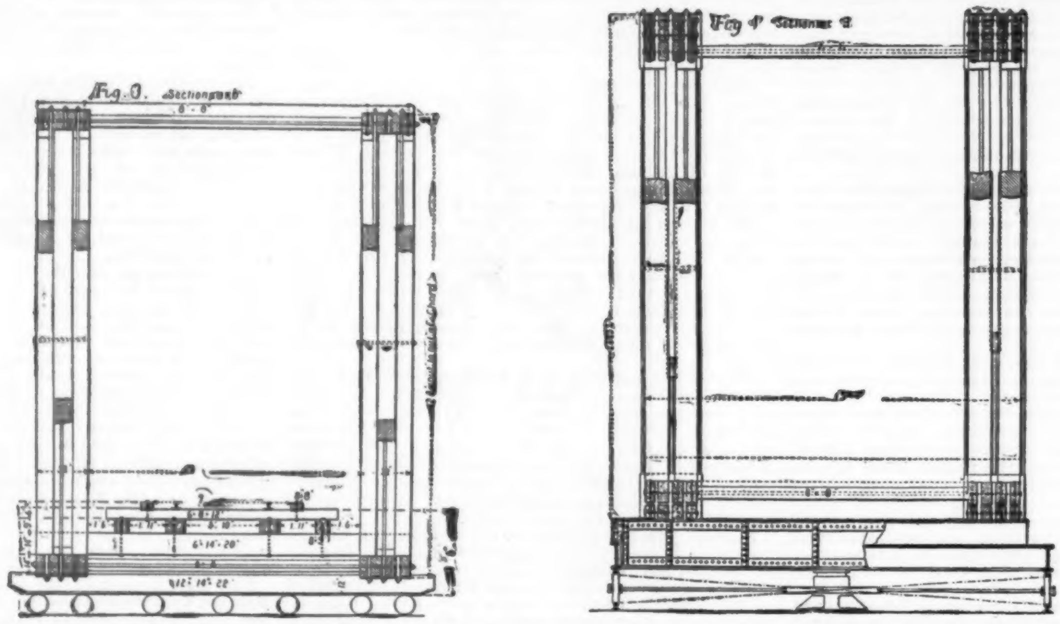
truss, to which their names have since become attached.

Towne's truss was such a remarkable and important improvement—the application, in fact, of a new mechanical principle in bridge building—that it was immediately extensively copied, the most important example being the bridge erected across the James River at Richmond, built by Mr. Moncure Robinson. The total length of this bridge was 2,900 feet. It was supported on eighteen granite piers at distances apart varying from 130 to 150 feet, the total cost being about $100,000. Other bridges on the same principle were built, one across the Susquehanna 2,200 feet, with span of 230 feet; another at Nashua, N. H.; at Newburyport, Springfield, Northampton, Philadelphia, Trenton; one near New York, another near Troy, and many others in the Southern and Middle States.

These bridges have nearly all disappeared, wrought iron having taken the place of timber, while the principle of Towne is still preserved in new constructions.

Of wrought iron bridges it is hardly necessary to treat at this time, since they belong to our own period, and are the work of engineers of our own day.—*Transactions of the N. Y. Academy of Sciences.*





HOWE TRUSS TIMBER BRIDGE ACROSS THE WILLAMETTE RIVER, ALBANY, OREGON.

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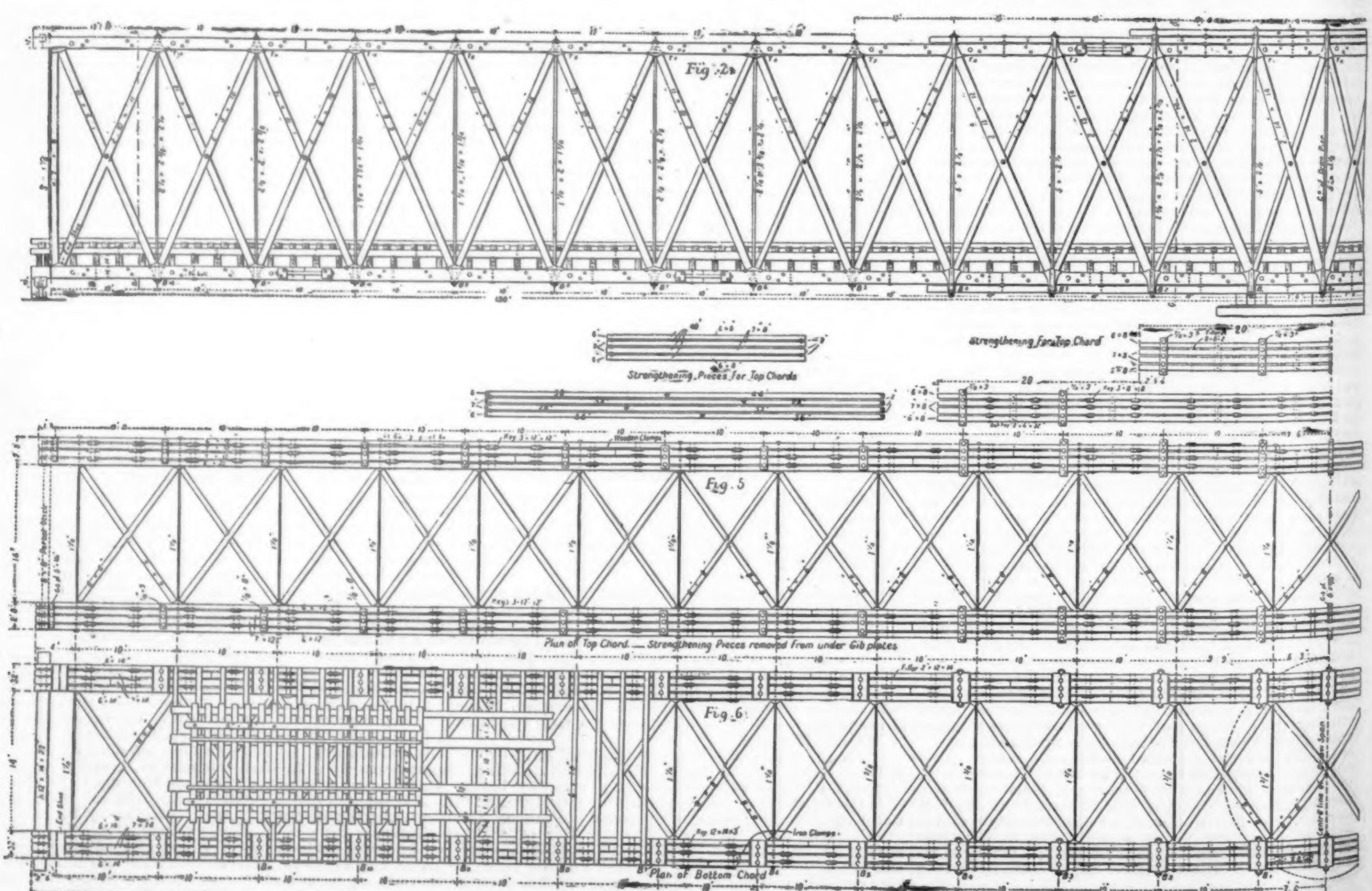
WE have been favored by Mr. J. Bernard Walker with the following particulars of a very interesting timber bridge built by the Oregon Pacific Railroad Company across the Willamette River, State of Oregon, U. S. A. The dimensions for a wooden bridge are, even for the United States, unusual, and the draw span, with its length of nearly 100 yards, is considerably the largest of its kind in the world.

The exigencies which demanded an immediate bridg-



HOWE TRUSS TIMBER BRIDGE ACROSS THE WILLAMETTE RIVER, ALBANY, OREGON.

ing of the river, the delay in sending to the East for material for an iron structure, the abundance of magnificent Oregon pine in the neighboring mountains, and lastly the conviction that, with a proper distribution of its bulk, timber would do its work of resisting strains of compression and tension with just the same certainty as steel or iron, led the company to construct the bridge of timber, not even inserting the customary iron draw span.

The total width of the river, 610 ft., is crossed by two Howe truss spans of 175 ft. each and a draw span of the same system 260 ft. in length, as shown in Fig. 1. The bottom of the bridge is 11 ft. clear of high water, and 42 ft. clear of low water line. The river piers, which carry the 175 ft. spans, consist each of 32 12-in. piles, and the draw span pier of 69 piles. These are driven through the surface gravel and penetrate from 15 ft. to 20 ft. into the underlying blue clay. The piling is surrounded by a casing of 12 in. by 12 in. timber, built in horizontal layers with a slope of 1 in 12. The space between casing and piling is filled with rock and gravel.

Resting upon the piling of the draw pier, which has a width at the top of 24 ft., are three layers of 12 in. by 12 in. timbers, and above these two layers of 4 in. planking. Upon this planking are placed the circular rail, 22 ft. in diameter, for the wheels and the central socket which receives the pivotal pin. Upon this pin, and at right angles to the length of the bridge, is placed the box girder, 2½ ft. deep, which receives at its ends the two bottom chords of the bridge; and it is so adjusted that the bulk of the weight of the bridge is transmitted to the central pin, the circle of wheels taking only sufficient load to give stability to the bridge in turning. The turning gear consists of the usual rack and pinion arrangement, and one man can open the bridge in two minutes or less.

The detail views, Figs. 2 to 6, will show the simplicity of the construction. The chords, top and bottom, consist of four pieces fastened together laterally by ¾ in. bolts, and secured from longitudinal play by hardwood keys tightly fitted, the ¾ in. bolts passing through the keys and securing the whole firmly together. Where the joints occur in the length of the chord pieces, they are held together by two iron straps, one on each side of the joint, which are tightened by jib and cottar. The lengths are so placed that the joints are evenly distributed, and never occur at the same point of section of the chord.

The diagonal braces and counters bed upon cast iron angle blocks, which are hollow, for lightness, but strongly ribbed within. The face of the angle block is plane, and set at right angles to the center line of the brace that beds upon it. Through these angle blocks, and between the chord-pieces, pass the vertical truss rods, which are tightened by nuts against wrought iron jib plates upon the outside of the chords.

To insure a camber of 5 in. on the 175 ft. spans the width of each panel is ⅜ in. greater at the top than at the bottom chord. The main braces are arranged in pairs, with the counters passing between them, and where the braces cross they are bolted together to insure lateral stiffness.

The weight of the bridge is one ton per foot, and it contains some 800,000 cubic feet of sawn timber. The time occupied in construction from the sawing of the timber to the passage of the first train was five months, and the whole work was carried through without a single accident.

The completion of this work marked an important step in the progress of the Oregon Pacific Railroad from its fine deep-water harbor on the Pacific toward its eastern connection with the Atlantic coast. Just now this enterprise is a central point of interest in the railroad circles in this country, for its success means the opening of another transcontinental line of road, and the development of some of the finest stock, grain and mineral land in this famous district of the "Northwest."—*Engineering*

LENOIR'S PETROLEUM BOAT.

THE steam engine had scarcely been invented when the idea occurred to apply it to navigation. Despite the difficulties of every nature presented by such a problem, it gradually became possible to render steam navigation practical, and during the same fifty years since the problem has been solved, it may be said that the study of marine engines has largely contributed to the improvement of steam motors. The gas engine, which came later, since it was not till about 1860 that Mr. Lenoir was the first to succeed in making it work, has not, from the first, seemed to be able to adapt itself conveniently and practically to the peculiar conditions of navigation. In fact, every gas motor supposes the presence of a gas works. Various attempts have been made in recent years to supply these motors with special gases, either water gas or gases produced by means of light petroleum oils; but, up to 1882, these diverse tentatives had met with little or no success. Here, again, Mr. Lenoir was ahead in being the first to run a boat actuated by petroleum, upon the Seine. This experiment had no outcome, the apparatus having disappeared during the war of 1870. In 1882, Mr. Lenoir again took up the question of gas motors, after abandoning it for more than twenty years. He went back to Beau de Rochas' idea of previous compression, and, in conjunction with the Messrs Rouart, devised a motor that saved thirty-five per cent. more gas than its most improved predecessors. It at once occurred to him to utilize petroleum vapors, and in a short time appeared the first petroleum motor operating with an economy comparable to that of the gas motors.

After this, the application of this engine to navigation depended merely upon a special adaptation of its parts. The Messrs. Rouart undertook the construction of a boat engine, which, after satisfactory trials of it on the Seine, was sent to the Havre Maritime Exhibition last April. The boat actuated by this engine is 23 feet in length, 5½ feet in width, and 3 feet in depth. It was launched last June, and after that period was daily operated for several hours, and that too with perfect regularity. At least twice a week, it made a trip from Havre to Tancarville, through the new canal, its ordinary speed being 8½ miles per hour (Fig. 1).

The engine (Fig. 2) consists of two simple acting cylinders, one above the other, actuating a vertical driving shaft. This arrangement permits of placing the fly wheel at the lower part, thus increasing the boat's stability. This important result, as may be seen, has been obtained in a very simple manner.

The screw is actuated by a series of gearings placed beneath the fly wheel and permitting of easily reversing or stopping the engine through a lever.

The two cylinders, although coupled upon the same shaft, are capable of operating independently of each other. In this way, great variations in speed are obtained at will, whenever there is occasion. The position of the fly wheel at the bottom of the boat made it difficult to start it, so it became necessary to fix to the upper part of the shaft a ratchet wheel, to which a rotary motion is given by means of a lever. This mode of starting the engine has given excellent results.

The petroleum vapor, which is cold and consequently in no danger of exploding, is produced in a cylindrical vessel placed at the side of the engine and actuated by the latter itself.

In the application under consideration, this motor presents great advantages over the steam engine. It is instantaneously set in motion without being previously put under pressure, as a steam engine is, and the stoppage is effected in the same way without the necessity of extinguishing the fires under a boiler. During stoppages, however long they be, absolutely nothing is consumed. Smoke, ashes, cinders, etc., are done away with, and consequently the apparatus of the boat is kept clean. There is absolutely no danger of explosion. Finally, the most prominent advantage as regards navigation is the great diminution in the weight of fuel to be carried. In fact, this motor consumes but about 12 ounces per horse and per hour to obtain a power of 3 horses, while a steam engine under the same conditions would use from 3½ to 8 pounds of coal. Moreover, the storage of the fuel is easy—a simple 8 gallon can of gasoline sufficing to assure a run of 10 hours.

Upon the whole, this apparatus constitutes a very interesting application of gas motors. It may be used not only for pleasure boats, but also for yawls, ships' boats, and perhaps life boats, while awaiting the construction of more powerful motors that will furnish new resources to navigation.—*La Nature.*

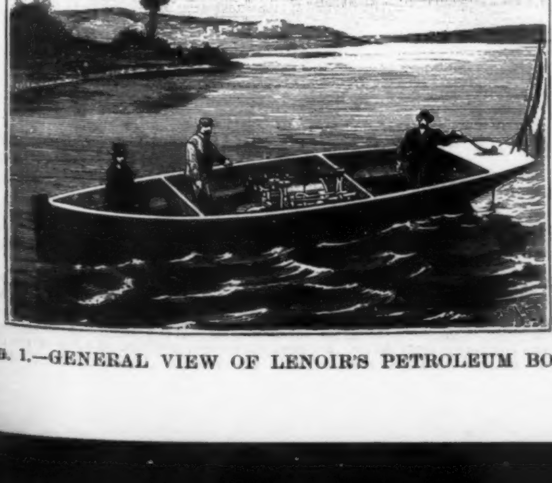


FIG. 1.—GENERAL VIEW OF LENOIR'S PETROLEUM BOAT.

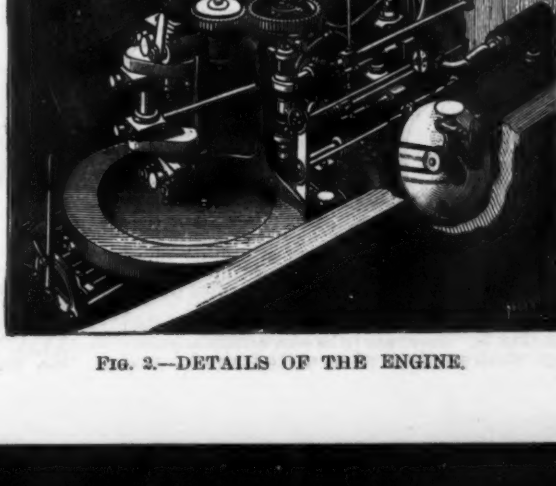
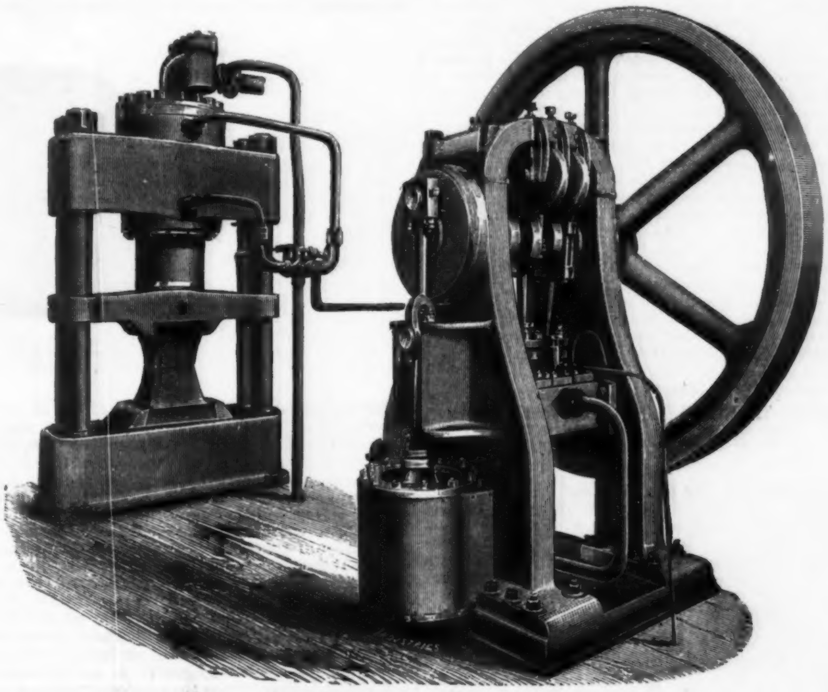


FIG. 2.—DETAILS OF THE ENGINE.

IMPROVED HYDRAULIC HAMMER.

AMONG the important exhibits of Messrs. Harfold & Co., of the Blaydon Iron Works, Blaydon-on-Tyne, shown at the late Newcastle-on-Tyne exhibition, were those illustrative of Higginson's patent direct system of utilizing hydraulic power. We illustrate above the principal of these specialties, viz., the 300 ton hydraulic hammer or squeezer, as well as the engine and pumps by which it was actuated. The latter was also employed in working three of Higginson's patent noiseless hydraulic winches, specially designed for use on passenger ships, which we hope to describe on another occasion. Considerable interest was centered in these exhibits, more especially on the hydraulic hammer or squeezer, as it embodies quite a new mode of applying hydraulic power for forging steel and iron ingots. It consists of a vertical cylinder 20¾ in. diamater, fitted with gun metal glands and steel studs and nuts, and capable of working to 2,000 lb. per square in. The cylinder is supported by four wrought steel columns, which form the guide for the crosshead of the ram, the whole being carried upon a massive cast iron bed plate. The ram is 19¼ in. diameter, 15 in. length of stroke, and is fitted with gun metal packing ring and studs. The cylinder is fitted with a valve box for controlling the water supplied from a tank, and an arrangement of valves and cylinders for automatically releasing the water when the maximum pressure has been reached. The engine and pumps consist of a vertical engine having a cylinder 16 in. diameter, 12 in. length of stroke, fitted with metallic packed piston, gun metal glands, neck bushes, drain cocks, and cased with sheet bronze. The crank and pump shaft are of steel, and carry a massive fly wheel, 9 ft. diameter, weighing 2¼ tons. The three-throw pumps have gun metal rams, 4 in. diameter, 6 in. length of stroke, and the valve box in connection is fitted with three gun metal suctions and three delivery valves with seatings, and fitted with spring relief valve.


HYDRAULIC HAMMER.

The arrangement of working is somewhat as follows: The ram is brought down to its work by a head of water, and as soon as the die comes upon the ingot to be forged, the pressure of the pumps comes into play, and the squeeze is completed by the momentum of the fly wheel. By this means a powerful and comparatively slow squeeze is obtained, and an accumulator is dispensed with, and more effect is gained than by a great number of blows from a steam hammer. When what we may term the pressure blow is complete, the hand lever is thrown out of gear by a self-acting valve and the ram is raised, then the ingot is turned partially round for another pressure blow, and so on until the ingot is reduced to the intended size.

There appear to be decided advantages in Higginson's system of applying hydraulic power, both as compared with the ordinary method of using hydraulic power by means of an accumulator and as compared with steam hammers. With one engine and pump several hammers can be worked, and the steam consumed by the engine is proportionate to the work done. The accumulator is dispensed with, causing great economy in working. Although this hammer may not appear to work so rapidly as a steam hammer, yet the amount of work actually performed is greater and more effective, as it has been found that, in dealing with large masses of steel, a powerful squeeze is more efficacious in consolidating the ingots than a succession of blows as applied by the steam hammer, as the blows, being comparatively light, produce a hardening and consolidating effect upon the external surface of the ingot, but leave the interior more or less porous. This latter defect, it is well known, has often caused steel forgings to be condemned after much valuable work had been expended on them. It may also be pointed out that in consequence of the hammer being self-contained the foundations needed are light and inexpensive, and there is an absence of noise and vibration. It is also noteworthy that by this system there is a constant circulation of water through the whole machine and back through the tank in connection with the pump, so that there is little liability of the water freezing.—*Industries.*

[NATURE.]

TIMBER, AND SOME OF ITS DISEASES.

By H. MARSHALL WARD.

I.

ON carefully examining the clean-cut end of a sawn log of timber, it is easy to convince ourselves of the existence of certain marks upon it which have reference to its structure. These marks will vary in intensity and number according to the kind of tree, the age at which it is felled, and some other circumstances, which may be overlooked for the present; but in a given case it would be possible to observe some such marks as those indicated in Fig. 1. In the specimen chosen there is a nearly central spot, the pith, around which numerous concentric lines—the "annual rings"—run. Radiating from the pith toward the periphery are cracks, the number and length and breadth of which may vary according to the time the log has been exposed to the weather, and other circumstances; these cracks are due to the contraction of the wood as it "shrinks," and they coincide with medullary rays, as lines of weakness. Between these cracks are to be seen numerous very fine radiating lines indicating the course of the uninjured medullary rays, which again will vary in distinctness, etc., according to the species of timber.

This log of wood, with its annual rings and medullary rays, is clothed by a sort of jacket, consisting of cork and softer tissues, and termed the cortex, or, more popularly, the "bark" (an unfortunate word, which has caused much trouble in its time). The largest of the cracks is seen to traverse the whole radius of the face of the wood from center to circumference, and also to pass through the cortex, which gapes widely.

The remaining cracks, however, stop short at a line which marks on the one hand the inner face of the cortex, and on the other the outer face of the wood; this line also represents the cambium, a thin sheet of generative tissue which remains after giving rise to practically the whole of the wood (a very little in the center excepted) and cortex visible in the woodcut. Since we are not concerned with the cortex and bark at present, it will be convenient to regard the log as "barked," and only deal with the wood or timber itself, in the condition to which the woodman reduces it after removing the cortex with certain implements.

If now we split such a log as Fig. 1 along the line of the big crack, neatly and smoothly, the well-known "grain" so often observed on planks of wood will come into view, and it will be noticed that the lines which mark the "grain" are continuations of the lines which mark the annual rings, as shown in Fig. 2, which represents on a larger scale a segment such as could be cut from a log in the way described. It is clear from comparison of what has been said, and of the two figures, that the "annual rings" are simply the expression in cross section of cylindrical sheets laid concentrically one over the other, the outermost one being that last formed. But on examining the medullary rays in such a piece of timber as that in Fig. 2, it will be noticed that they also are the expression of narrow radial vertical plates which run through the concentric sheets; the medullary rays are in fact arranged somewhat like the spokes of a paddle wheel of an old steamer, only they differ in length, breadth, and depth, as seen by comparing the three faces of the figure. It is to be noticed that the medullary rays consist of a different kind of tissue from that which they traverse, a fact which can only be indicated in the figure by the depth of shading. It is also to be observed that the "annual rings" show differences in respect to their tissue, as marked by the darker shading near the boundary lines on the outer margin of each ring. In order to understand these points better, it is necessary to look at a piece of our block of timber somewhat more closely, and with the aid of some magnifying power. For the sake of simplicity it will be convenient to select first a piece of one of the timbers known as "deal" (firs, pines, etc.), and to observe it in the same direction as we commenced with, *i. e.*, to examine a so-called transverse section.

The microscope will show us a figure like that in the woodcut (Fig. 3). There are to be seen certain angular openings, which are the sections of the long elements technically called *tracheides*, shown in elevation in Fig. 4. It will be noticed that whereas along some parts of the section these openings are large, and as broad in one direction as in the other, in other parts of the section the openings are much smaller, and considerably elongated in one direction as compared with the other. The band of small openings naturally looks more crowded and therefore darker than the band of larger openings, and it is to this that the differences in the shading of the annual rings in Fig. 2 are due. But it is not simply in having larger lumina or openings that the dark band of tracheides is distinguished from the lighter one; the walls of the tracheides are often also relatively thicker, and obviously a cubic millimeter of such wood will be denser and contain more solid substance than a cubic millimeter of wood consisting only of the larger, thin-walled tracheides. It is equally obvious that a large block of wood in which the proportion of these thick-walled tracheides with small lumina is greater (with reference to the bands of thin-walled tracheides) will be closer-grained, and heavier, than an equal volume of the wood where the thin-walled tracheides with large lumina predominate. Since their study would need an article to themselves. It must suffice for the present to state that the markings have reference to the minute structure of the cell walls, and the depressions are very beautiful and complicated pieces of apparatus to facilitate and direct the passage of water from the cavity of one tracheide to that of another. Now, the cambium is a thin cylindrical sheet of cells with very delicate walls, each cell having the form of a rectangular prism with its ends sharpened off like the cutting edge of a carpenter's chisel. This prism is broader in the direction coinciding with the plane of the sheet of cambium—*i. e.*, in the tangential direction, with reference to the trunk of the tree—than in the direction of the radius of the stem; and the chisel edge must be supposed to run in the direction parallel to that of a medullary ray, *i. e.*, radially. From the first, each cambial cell contains protoplasm and a nucleus, and is capable of being nourished and of growing and dividing. It is only at or near the tips of the branches, etc., that these cambium cells are growing much in length, however; and in the parts we are considering they may be for the most part regarded as growing only in the radial direction;

FIG. 1.—A log of timber, showing radial cracks after lying exposed for some time. *a*, a large crack extending from pith to circumference; *b*, the cortex; *c*, medullary ray; *d*, cambium; *e*, annual ring; *f*, outer bark, proper. Reduced.

Returning now to the section (Fig. 3), it is to be observed that the differences in the zones just referred to enable us to distinguish the so-called "annual rings." The generally accepted explanation of this is somewhat as follows. In the spring time and early summer, the cambium cells begin to divide, and those on the inner side of the cylinder of cambium gradually become converted into tracheides (excepting at a few points where the cells add to the medullary rays), and this change occurs at a time when there is (1) very little pressure exerted on the inner parts of the trunk by the cortex and corky bark, and (2) only comparatively feeble supplies are derived from the activity of the leaves and roots, in the still cool weather and short days with little sunlight. In the late summer, however, when the thickened mass of wood is compressed by the tightened jacket of elastic bark which it has distended, and the long, hot, bright sunny days are causing the numerous leaves and roots to supply abundance of nutriment to the growing cambium cells, it is not surprising that these cells cannot extend themselves so far in the radial direction (*i. e.*, in a line toward the center of the compressed stem), and that their walls are thickened by richer deposits of woody material supplied quickly to them.

As the winter approaches, the cambium ceases to be active, and it then remains dormant for several months. When its cells are awakened to renewed growth and division in the following spring, they at once begin to form the tracheides with thin walls and large lumina, and it is the sharp contact thus displayed between the newly-formed tracheides with thin walls and large lumina and the compressed denser ones on which they suddenly abut, that produces the impression of the "annual ring."

It is now time to attempt to give some clearer ideas of what this "cambium" is, and how its cells become developed into tracheides. But first it is necessary to point out that each tracheide is a long, more or less tubular and prismatic body, with bluntly tapering ends, and the walls of which have certain peculiar markings and depressions on them, as seen in Fig. 4. We cannot here go into the important signification and functions of these markings and depressions, however, more rarely, and to a slight extent, in the tangential direction also, as the circumference of the cylinder enlarges. After a cambial cell has extended its walls by growth in the radial direction to a certain amount, a septum or a division wall arises in the longitudinal tangential plane, and two cells are thus formed in place of one; this process of division may then be repeated in each cell, and so the process goes on. This is not the place to lay stress on certain facts which show that a single layer of cells initiates the division; it suffices to point out that by the above process of division of the cambial cells there are formed radial rows of cells, as indicated in Fig. 5, where the arrow points along a radius toward the center of the stem. It is true such radial rows of cells are also developed in smaller numbers toward the outside of the cambium cylinder (*i. e.*, to add to the cortex), but we are only concerned with the wood, and therefore only regard those cells which are developed on the inside (*i. e.*, toward the center of the stem). After a time the oldest of these cells (*i. e.*, those nearest the center of the stem) cease to divide, and undergo changes of another kind; the process of division is still going on in the younger ones, however, and so the radial rows are being extended by additions of cells at their outer ends. Of course, this is normally proceeding along the whole area of the cylindrical sheet of cambium, and therefore over the whole of the stem and roots, with their branches.

Confining our attention to one of the innermost, oldest cells of the cambium, which has ceased dividing (as in Fig. 5), we find that it enlarges somewhat in the radial direction, and then its hitherto very thin walls become thicker; in fact, the protoplasm in its interior absorbs food materials and then changes them into a peculiar substance which it plasters or builds on to the inner sides of the cell wall, so to speak, until the wall is much thicker. This thickening process is withheld at certain places only—the thin depressions already referred to. Two chief changes result now: (1) the whole of the living contents of the young wood cell gradually become used up, and eventually disappear without leaving any trace; and (2) the thickening substance built on to the inside of the walls undergoes changes which convert it into true wood substance—in botani-

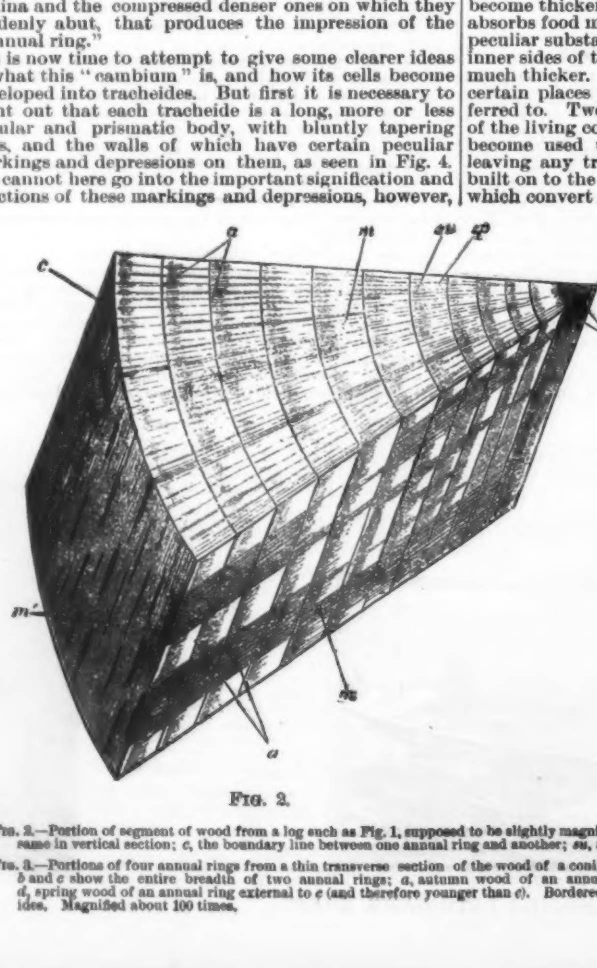


FIG. 2.

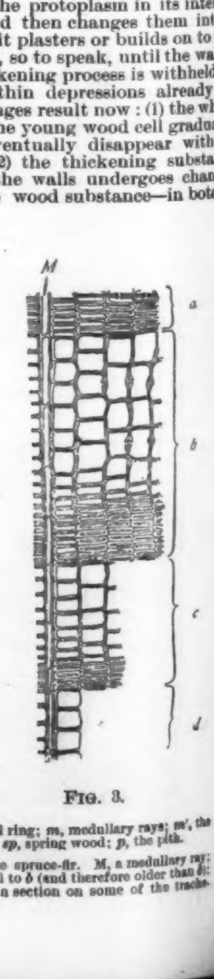


FIG. 3.

FIG. 2.—Portion of segment of wood from a log such as Fig. 1, supposed to be slightly magnified. *a*, annual ring; *m*, medullary rays; *m'*, the same in vertical section; *c*, the boundary line between one annual ring and another; *su*, autumn wood; *sp*, spring wood; *p*, the pith.

FIG. 3.—Portions of four annual rings from a thin transverse section of the wood of a conifer, such as the spruce-fir. M, a medullary ray; *b* and *c* show the entire breadth of two annual rings; *a*, autumn wood of an annual ring internal to *b* (and therefore older than *b*); *d*, spring wood of an annual ring external to *c* (and therefore younger than *c*). Bordered pits are seen in section on some of the tracheides. Magnified about 100 times.

cal language, the walls become lignified. The cells, *b* and *c*, in Fig. 5, illustrate what is meant.

During all these changes, which occupy several or even many hours or days, according to circumstances, it will be observed that the definite shape of the cell is gradually completed, and then alters very little: the prismatic cambium cell has become a prismatic tracheide, with thicker, lignified walls, and containing air and water (with minute quantities of mineral substances dissolved in it) in place of protoplasm and nutritive substances. It is not necessary here to speak of other and more subtile changes which cause slight displacements, etc., of these cells.

If I have succeeded in making the chief points in this somewhat complicated process clear, there will be little difficulty in explaining what occurs in other parts of the cambium cylinder. The cambium cells which happen to stand in the same radial row as the cells of a medullary ray simply go on being converted into cells of the medullary ray, instead of into tracheides; cells which differ from the tracheides chiefly in retaining their living contents and nutritive materials—*i. e.*, substances like starch, proteids, sugars, etc., which are used as food by the plant. Again, those cells of the cambium which are divided off on the outer side of the cylinder (they are always fewer in number) are gradually transformed into elements of the cortex, and finally enter into the composition of the bark proper.

Now and again, but much more rarely, a radial row of cambial cells which, from their position, it would appear should be converted into tracheides of the wood, alter their destiny, so to speak, and become the originators of a new medullary ray. But I must pass over these and some other minor peculiarities, and refer to the illustrations for further details.

If now, instead of a log of deal, or coniferous wood, we direct attention to the timber of a dicotyledonous tree, such as the oak, ash, beech, chestnut, poplar, etc., the differences in detail will not be found very great in relation to the broad features here under consideration. Turning again to Fig. 1, it would be possible to select a cut log of any of these timbers which presented all the salient characters there exhibited. The bark would present external differences in detail—such as in roughness, color, thickness, etc.—but it could still be described, as before, as a more or less corky jacket around the whole of the wood: the cut face would show the timber marked by more or less numerous and prominent "annual rings," traversed by smaller or larger medullary rays, radiating from the central pith, and passing across the cambium to the cortex. Moreover, cracks would be apt to form on exposure, as before; the opening occurring along the lines of medullary rays—lines of weakness.

Again, if we cut a segment of the wood, like Fig. 2, the chief features would present themselves as there shown, and the lines of demarkation indicating the annual rings would be found to be due to the sharp contrast between the spring wood and the autumn or summer wood, as before.

On closely examining a transverse section of such a piece of timber, however, we should find differences which at first sight appear profound, but which on reflection and comparison turn out to be of more relative significance, from the present point of view, than might be expected.

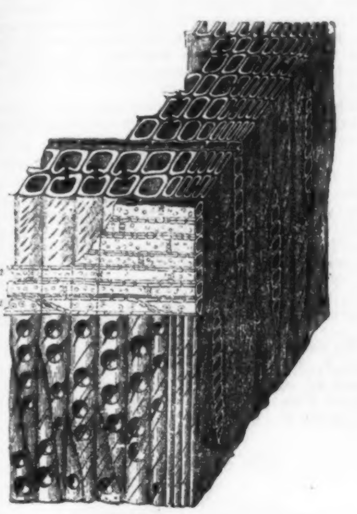


FIG. 4.

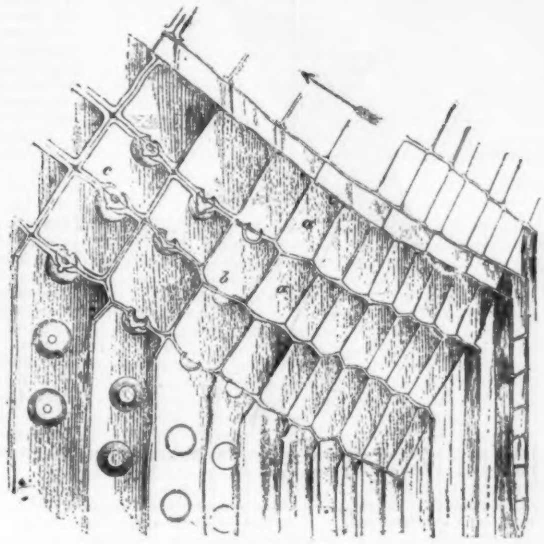


FIG. 5.

FIG. 4.—A small block of wood from a spruce-fir, supposed to be magnified about 100 times, showing elevation and sectional views of the tracheides of the autumn (to the right) and spring wood, and medullary rays (*m n*) running radially between the tracheides. (After Hartig.)

FIG. 5.—Portion of cambium of a fir, showing the development of the young wood tracheides from the cambium cells. The arrow points to center of the stem. The cambium cells at length cease to divide, and the walls become thicker (*a*), except at certain areas, where the bordered pits are developed (*b* and *c*). To the right is a medullary ray. Highly magnified, and the contents of the cambium cells omitted for clearness.

FIG. 6.—A piece of wood from a dicotyledonous tree (beech), supposed to be magnified about 100 times. *Mr*. a medullary ray running across the transverse section: the dark band crossed by this ray is the autumn wood (*a*), formed of closely crowded wood fibers and tracheides; *v*, a large vessel in section: others are seen also—they are smaller and fewer toward the autumn wood; *a'*, wood fibers, of which most of the timber is composed; *wp*, wood parenchyma cells.

Selecting a given example, that of the beech for instance, the first difference which strikes us (Fig. 6) is a number of relatively very large openings on the transverse section: these are the vessels—pitted vessels—long tubular structures which are not formed by the cambium of the conifers. Between these vessels are much more numerous elements with very small lumina and thick walls; the latter are the wood fibers proper, and have to be technically distinguished from the apparently somewhat similar wood tracheides of the pines, firs, etc. Here and there, scattered in small groups, are certain rows of shorter cells, which, however, are not very numerous in the beech; they are called wood parenchyma (Fig. 6, *wp*), and occur particularly in the vicinity of the vessels.

It is beside the purpose here to describe in detail the histology of the beech wood, and reference may be made to the figures for further particulars. It may suffice to say that all the elements—cells, fibers, and vessels—are formed as before by the gradual development of cambium cells, and the same is true, generally, of the medullary rays here that is true of those of the pines and firs, etc.

Attention is to be directed to the fact, which is here again evident, that the line of demarkation between any two "annual rings" is due to the sudden apposition of non-compressed elements upon closely packed and apparently compressed elements; the latter were formed in the late summer, the former in the spring. Moreover, the spring wood usually contains more numerous vessels, with larger lumina than the autumn wood; in this particular case, again, the fibers of the autumn wood are darker in color. It should be stated, however, that many dicotyledonous trees show these peculiarities much more clearly than the beech; others, again, show them less clearly.

Now it is obvious that, other things being equal, the spring wood, with its more numerous and larger vessels, and its looser tissue generally, will yield more readily to lateral pressure and strains than the denser autumn wood; and the like is true of the pines and firs—the closely packed, thick-walled tracheides of the autumn wood furnish a firmer and more resistant material than the larger, thinner-walled tracheides of the spring wood. To this point we shall have to return presently.

GLASS BOTTLE MAKING BY MACHINERY.

AT the invitation of Messrs. Sykes, Macvay & Co. (Limited), a representative of *The Chemist and Druggist* recently joined a party of about forty journalists bound for the firm's works at Castleford, in Yorkshire, to inspect a new machine for making glass bottles, which, if it should realize the expectations of the inventors, is destined to restore to this country an industry that has suffered heavily for many years from the competition of the low priced labor of Germany and Belgium.

It is claimed that out of an estimated average daily production of 46,432 gross of glass bottles, this country only produces 6,206 gross, against about five times that number manufactured in Germany and Belgium. But it is anticipated that this state of things will be completely changed by the introduction of the bottle making machine invented by a Yorkshireman named Howard Matravers Ashley. This gentleman, in conjunction with a friend, has made arrangements with the firm of Sykes, Macvay & Co., by virtue of which the latter will work his invention and manufacture both the machines and the bottles. Mr. Ashley, who personally conducted the party from their arrival at the Castleford works until their departure in the evening, with excusable pride immediately showed his guests to the new machine, although many of them, to judge by their questions and observations upon having its working explained, would have had their powers of comprehension greatly assisted had they previously obtained an insight into glass bottle making by the accustomed process.

This method, which several of the party subsequently had an opportunity of inspecting, under the guidance of one of the partners in the firm, may be briefly described as follows:

The glass "metal" is heated to a semi-liquid state in large fireclay pots of peculiar construction, into which one of the set of five hands required for turning out the bottles dips an iron tube about seven feet in length, collecting at the end of it such a quantity of the fused substance as will make a bottle of the size required. This first hand, technically known as the "gatherer," hands the tube to the blower, who, blowing in it meanwhile, shapes it roughly into a conical form on a smooth sloping stone slab. The "metal" is next quickly placed by this workman into a small hole in the floor of the workshop, in which there is an iron mould divided longitudinally and hinged at the base, connected with a chain running upward like a bell pull. This the blower pulls, and thereby closes the mould round the heated glass. He then again vigorously blows through the tube until the embryo bottle has attained the shape of the mould, when by another tug at the chain it is released from the mould and handed to a boy. The latter, known as the "wetter-off," by means of a moistened steel file or chisel separates the bottle from the tube and hands it to the fourth workman, whose share in the manufacture requires the greatest dexterity of all. It is his business to trim the ragged neck and add to it a ring or lip. This he accomplishes by means of an instrument known as a "punty," a kind of four-fingered iron claw at the end of a rod, into which the bottle fits exactly, the four claws reaching just to the neck of the bottle.

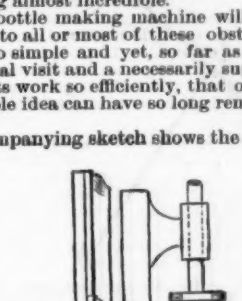
With the punty the bottle is pushed into a furnace and held there until the glass of the neck becomes soft. Then the "maker" applies some more molten metal round the neck, with which he forms the ring, and shapes it by means of a moulding tool called shears, consisting of a tongue fitting into the neck of the bottle, and two blades which are tightened round the neck. With this, while the bottle is being rapidly rotated with the tongue for its axis, he quickly shapes the ring.

The fifth hand of the set then takes the bottle and places it with others into an annealing oven, which is heated to a very high temperature, and is allowed to cool gradually, two or three days being required for this purpose, when those that have withstood all tests and literally passed unscathed through the fiery furnace are ready for the market.

The process above described, though followed with little deviation at all glassworks, has many evident drawbacks. One great disadvantage is the waste of glass metal, computed at something like thirty per cent. The bulk of this is, of course, collected again, but in remelting its quality deteriorates considerably. The blowing of the bottles is said to be an occupation almost as unhealthy as any in the manufacturing industries, although the blower, who at the time of our visit was turning out pickle bottles at an almost incredible speed, assured us that he had been following his occupation for nearly forty years. As about eighty-four dozen bottles are considered a fair day's work, and the men labor five days a week, it follows that this man must have turned out the extraordinary number of over ten millions of bottles, the strain upon his constitution represented by so many violent pulmonary efforts being almost incredible.

The new bottle making machine will, it is thought, put an end to all or most of these obstacles. The apparatus is so simple and yet, so far as can be judged from a casual visit and a necessarily superficial inspection, does its work so efficiently, that one marvels how such a simple idea can have so long remained unappreciated.

The accompanying sketch shows the principle which



underlies Mr. Ashley's invention, and represents the machine as it is working at present, though several improvements have already been patented by the inventor, and the completed machine will probably be in working order early in the spring. The principal parts of Mr. Ashley's machine are a parison mould, A, which can be drawn into a bell by means of a lever, and hermetically closed, the halves being supported by two arms. To the mould is attached a movable end, connected with an air pump, by which a vacuum can be created within the mould. The molten glass is poured into the parison mould, which holds the exact quantity required to manufacture a bottle. Another mould, called the "collar mould," B, which is placed at the bottom of the parison mould, serves to mould the lip of the bottle. Air, forced by a pump which is connected (*u*) with the stand upon which the machine is

supported, is introduced into the hollow central part of the mould, the molten glass being prevented by a button from entering the latter. The lip of the bottle is shaped first, and the mould is then quickly reversed, causing the molten glass to fall down by its own weight. When the mass has descended to the length required, the halves of the mould are closed on it, a current of air from the pump is turned on, and the bottle quickly blown into the shape of the mould. A different mould is, of course, required for each kind of bottle.

The principal improvement which it is proposed to introduce into the machine now at work is to fix a number of machines—say four, six, or more—on a revolving stand, turning round as quickly as possible, one man being continually employed filling the moulds with the glass metal, another working the air pump and closing the moulds, and a third taking out the finished bottles.

The first result of the introduction of the perfected machines will be to diminish the number of hands employed; but as a large increase of orders is anticipated, owing to the impossibility of foreign competition, which now supplies this country with about 16,000 gross of bottles per day, or two and a half times as much as we ourselves manufacture, it is thought that the growth of business will quickly necessitate the employment of even a larger number of hands than are now engaged.

The inventor of the machine claims that the producing capacity of Messrs. Sykes, Macvay & Co.'s works, if sixty machines were set at work (one for each "hole" now existing), would be increased tenfold, or from 5,400 to 54,000 dozen bottles per day, while, instead of 300, only 180 hands would be required, and the cost of labor would be reduced from 3s. 10d. to 3d. per gross.

The exploiters of the patent propose to allow other firms to use the machine upon payment of a royalty, but all the machines will be made at the Sykes-Macvay works, and duly numbered and registered.

Mr. Ashley's partner in the patent, in the course of conversation, told our representative that, when they first asked permission from bottle manufacturers to put the invention to a practical test, they were everywhere received with suspicion, and found all works closed against them. As it was impossible to obtain a proper supply of molten glass without the employment of expensive fireclay pots, the erection of ovens and other preliminaries involving a heavy expenditure, it was resolved to use a mixture of molten shellac and resin instead of the glass metal. The inventor then constructed an improvised machine in an empty blacksmith's shop, and there succeeded in manufacturing excellent bottles from the shellac and resin mixture. These were shown to Messrs. Sykes, Macvay & Co., who thereupon decided to take the matter up.

THE POLAR PLANIMETER—ITS THEORY AND ITS USE.*

By E. A. GIESELER, C.E.

BY means of this instrument the area of any regular or irregular plane figure can be found by running the tracer once around the circumference of it. In the following the writer has attempted to give the theory of this useful device in a more simple way than it is generally given.

The instrument consists of a system of two bars, F I and I T, rotating around the fixed fulcrum, F; see Fig. 1.

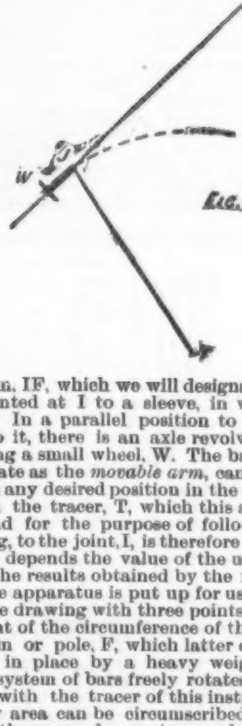


FIG. 1.

One of them, IF, which we will designate as the *polar arm*, is jointed at I to a sleeve, in which slides the other bar. In a parallel position to such sleeve, and attached to it, there is an axle revolving in bearings and carrying a small wheel, W. The bar, I T, which we will designate as the *movable arm*, can be shifted and clamped in any desired position in the sleeve; the distance from the tracer, T, which this arm carries at its extreme end for the purpose of following the lines of the drawing, to the joint, I, is therefore variable, and on its setting depends the value of the unit in which are expressed the results obtained by the instrument.

When the apparatus is put up for use, it rests on the plane of the drawing with three points, viz., the tracer, T, one point of the circumference of the wheel, W, and the fulcrum or pole, F, which latter consists of a ball joint held in place by a heavy weight, and around which the system of bars freely rotates. It is at once clear that with the tracer of this instrument the contour of any area can be circumscribed, provided that the size of the same does not exceed the limit of the apparatus, and further, that the position of the fulcrum has been properly chosen. This can be selected either *inside* or *outside* of the figure the area of which is to be found, both of which cases must be considered separately.

1. *When the fulcrum is outside of the area.*—In Figs. 2 and 3, A represents the figure the area of which is to be found; the instrument, with its fulcrum *outside*, is shown in various positions, the sleeve carrying the wheel having been left out so as not to unnecessarily complicate the diagrams.

Let us suppose the starting point of the tracer to be at the extreme left of the area, so that on being started on its path around it, in the direction of the arrow, its new positions will be to the right of the extended line I T.

* Copyrighted.

Now the journey of the tracer around the entire contour may be considered as consisting of two distinct parts. *First*, the part in which the tracer travels from its first, the above described extreme left position, along the upper part of the contour until it arrives at the extreme right position, from which any further movement will bring it to the left of the then position, T^3 I^3, of the movable arm. *Secondly*, that part in which the tracer travels from the extreme *right* position along the lower part of the contour until it arrives once more at the starting point. The first part of the tracer's journey is represented in Fig. 2, the second part in Fig. 3; in both diagrams two intermediate positions of

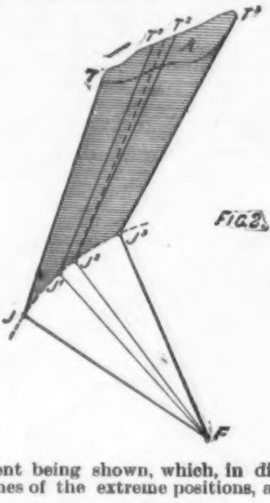


FIG. 2.

the instrument being shown, which, in distinction to the heavy lines of the extreme positions, are drawn in light lines.

In order now to investigate what takes place during the first part, represented in Fig. 2, we will consider the movement of the arm from the intermediate position, T^1 I^1, into an immediately adjoining one, T^2 I^2. This movement can be resolved into two components, viz., a progressive one, the direction of which is perpendicular to the arm and by means of which it arrives at the dotted position parallel to T^1 I^1, and a rotating one, by means of which it is turned from such dotted position into the actual new position, T^2 I^2. If now we assume that both these movements always take place in the

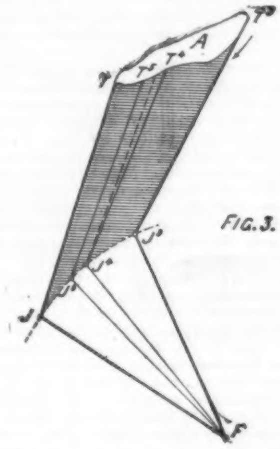


FIG. 3.

direction of the arrow, and that during the entire voyage of the arm from one extreme position into the other extreme position there is never a retrograde movement in the opposite direction, then we perceive that the shaded area in Fig. 2 can be expressed as the sum of the small parallelograms and sectors into which each space inclosed between two successive positions can be resolved. When it is further considered that the first movement of the arm, during which the space of the parallelogram is covered, is at right angles to it, then it appears clear that during such movement the wheel must roll off an arc, the length, *r*, of which is equal to the height of such parallelogram, the area of which latter is therefore equal to M *r*, M being the length of the movable arm. We have accordingly:

$$\text{Shaded area Fig. 2} = \text{M} \times \text{sum of the various } r + \text{sum of the various sectors.}$$

The same line of argument will lead to a similar equation for the shaded area in Fig. 3, and as the difference between these two shaded areas is equal to the area inclosed by the curve, we obtain an expression for this latter by subtracting the second equation from the first one. This expression will be made up of two terms, one containing the parallelograms and the other containing the sectors.

In regard to the last term, it is clear that the sum of the sectors in Fig. 2 must be equal to the sum of the sectors in Fig. 3, the movable arm having made the same number of rotatory motions in each case; the sectors therefore annul each other. It is equally clear that the length rolled off by the wheel during the rotatory movements must be the same in both cases, the sum of the various sector angles being the same in Fig. 2 as in Fig. 3, and as their lengths are rolled off in opposite directions, they will also annul each other; or in other words, if it were only for the motions made while covering the sectors, the wheel at the end of its journey would be found not to have rolled off any length whatever.

The term containing the sectors annulling itself, the expression for the area inclosed by the curve is now reduced to the term containing the parallelograms, that is—

$$\text{Area} = \text{M} \left\{ \begin{array}{l} \text{sum of the various } r\text{, Fig. 2} - \\ \text{sum of the various } r\text{, Fig. 3} \end{array} \right\}$$

As the sectors do not cause any length at all to be rolled off by the wheel, the difference in the brackets is clearly equal to the entire amount which the wheel will be found to have rolled off on its return to the original position, and designating this amount with R, we now have the simple equation—

$$(1) \ldots\ldots\ldots\ldots\ldots\ldots \text{Area} = \text{M R}.$$

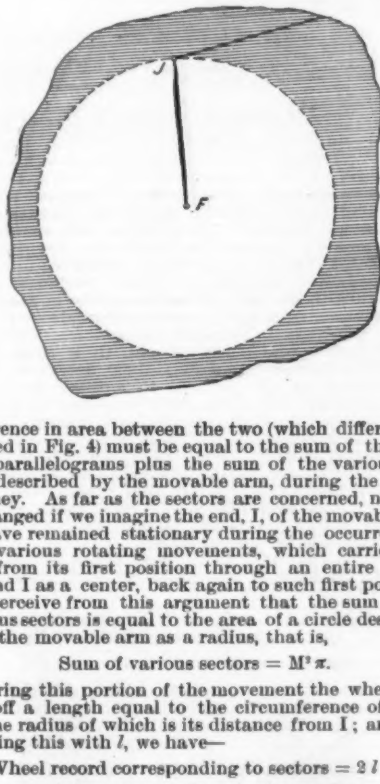
That is, the area inclosed by the curve is equal to the area of a rectangle with the length of the movable arm as a base and the length rolled off by the circumference of the wheel as its height.

In the above deduction the shape of the curve has been assumed to be such that the progressive motion of the movable arm from the left to the right in Fig. 2, and from the right to the left in Fig. 3, is never interrupted by any temporary retrograde movement, at any of the intermediate positions. This state of affairs, however, very rarely obtains in reality. The various positions of the movable arm will, on the contrary, cross and recross each other frequently, and the arm will often change the direction of its motion. But it is easy to prove that these complications do not alter the result of our deductions in the least.

In each case of a retrograde movement of the movable arm, a portion of the wheel record will be annulled, such portion representing a certain portion of the shaded area in either Fig. 2 or Fig. 3, according to whether the retrograde movement takes place in the first or in the second part of the journey. But it is clear that the movable arm will eventually have to pass over precisely the same area again, thus restoring the annulled portion of the wheel record. All retrograde movements will, therefore, cause certain amounts to be added to, and precisely the same amounts to be subtracted from the shaded areas, as well as the wheel record. The final result therefore remains unaffected for both.

2. *When the fulcrum is inside of the area.*—In this case the end, I, of the polar arm will describe a full circle instead of an arc, as in the first case. Suppose now that this circle is inclosed entirely by the curve itself, as shown in Fig. 4, then it is clear that the

FIG. 4.



difference in area between the two (which difference is shaded in Fig. 4) must be equal to the sum of the various parallelograms plus the sum of the various sectors described by the movable arm, during the entire journey. As far as the sectors are concerned, nothing is changed if we imagine the end, I, of the movable arm to have remained stationary during the occurrence of the various rotating movements, which carried the arm from its first position through an entire circuit around I as a center, back again to such first position. We perceive from this argument that the sum of the various sectors is equal to the area of a circle described with the movable arm as a radius, that is,

$$\text{Sum of various sectors} = \text{M}^2 \pi.$$

During this portion of the movement the wheel will roll off a length equal to the circumference of a circle the radius of which is its distance from I; and designating this with *l*, we have—

$$\text{Wheel record corresponding to sectors} = 2\, l\, \pi.$$

The remaining part of the wheel record, according to our previous deductions, must be the sum of the heights of the various small parallelograms.

Designating as before the entire wheel record with R, we therefore obtain—

$$\text{Sum of heights of parallelograms as given by wheel record} = \text{R} - 2\, l\, \pi.$$

And further—

$$\text{Sum of the various parallelograms} = \text{M}\,(\text{R} - 2\, l\, \pi).$$

The sum of the various parallelograms plus the sum of the various sectors renders the contents of the shaded area, consequently—

$$\text{Shaded area Fig. 4} = \text{M}\,(\text{R} - 2\, l\, \pi) + \text{M}^2 \pi.$$

And adding to this the contents of the circle described with the polar arm, P, as a radius, we clearly obtain the entire area inclosed by the curve—

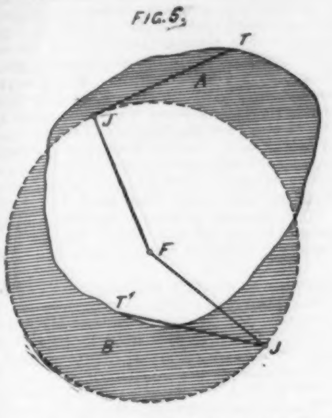
$$\text{Entire area} = \text{M}^2 \pi + \text{P}^2 \pi + \text{M}\,(\text{R} - 2\, l\, \pi) \quad \text{or}$$

$$(2) \quad \text{Entire area} = \text{M R} + \pi\,(\text{M}^2 + \text{P}^2 - 2\, \text{M}\, l)$$

The second term on the right side of this equation is a constant for each setting of the movable arm, the other two values, P and *l*, always remaining the same. The area is therefore found to be equal to a rectangle with the length of the movable arm as a base and the length rolled off by the circumference of the wheel as its height *plus* a certain constant.

The circumstances are not materially altered when the circle described by the movable arm is not inclosed entirely by the curve, as shown in Fig. 5. The difference between their areas in this case is equal to the difference between the two shaded areas, A and B, and this latter difference is equal to the arithmetical sum of the various parallelograms and the various sectors; this will appear quite clear when it is remembered that aside from temporary retrograde movements, A will be covered by the movable arm advancing and the wheel rolling in a direction opposite to both me-

tions while covering B. The difference of the area of the circle and the area of the curve will therefore be in this case, as before, equal to the arithmetical sum of the various parallelograms and the various sectors, the rest of the deduction remaining precisely the same as in the foregoing case.



For practical use it is desirable that with the fulcrum *outside* of the area the wheel record should render the latter direct, without the multiplication with the length of the movable arm being required. This can be done by a proper adaptation of such length as follows.

Suppose, for instance, the diameter of the wheel to be ¾", then the wheel record for n revolutions is

$$R = n \frac{3}{4} \pi = 2{\cdot}356\, n$$

and by substituting this into equation (1) we find:

$$\text{Area} = 2{\cdot}356\, M\, n$$

In order now to let n indicate the result directly, all that is required is to make the product 2·356 M equal to either 1 or 10 or 100 or any other power of 10. Suppose we assume

$$2{\cdot}356\, M = 10, \text{ then we have } M = \frac{10}{2{\cdot}356} = 4{\cdot}2$$

That is, when the length of the movable arm is made 4¼ inches, then each revolution of the wheel will indicate an area of 10 square inches. The circumference of the wheel is graduated into 100 parts, and by means of a vernier the one thousandth part of one revolution can be read, so that in the case of the setting discussed just now, each vernier unit would correspond to the hundredth part of a square inch. A small horizontal disk, connected with the axle of the wheel by means of a worm, keeps a record of the number of revolutions up to ten. The reading to be taken at the commencement of a measurement therefore consists of four figures, viz., the disk figure, the tenths and the hundredths of the wheel circumference, which are read on it direct, and the thousandths, which are read by means of the vernier. Suppose that with the fulcrum outside of the area and with the above setting of the movable arm, the reading at the commencement of a measurement was 4269, and that the reading taken after the tracer had traveled around the entire contour was 5374, then the difference between the two readings is 1105, which shows the area to be 11·05 square inches.

It is indifferent in which direction the tracer is taken around the contour; if taken as the hand of the watch travels, then the first reading has to be deducted from the second, and *vice versa*.

In practice the above described method of obtaining the setting of the instrument, besides being too time-robbing, is open to the objection that the requisite measurements cannot ordinarily be made with sufficient accuracy. The planimeters sold by the firm of Keuffel & Esser, of this city, are each accompanied by a table giving a limited number of settings, the figures of which table correspond to a graduation engraved on the movable arm. Any settings not contained in this table are found by trial, for which purpose a trial disk is furnished, the grooved rim of which incloses a known area and around which the tracer can be carried with exactitude.

The constant for inside positions of the fulcrum is found by measuring with an inside position a regular figure such as a square or a circle, the contents of which can easily be found by computation. The difference between the actual contents and the contents as given by the planimeter, or more precisely the difference between the wheel record with the fulcrum outside and that with the fulcrum inside, will be the constant. Care must be taken to note whether the wheel record in the second case is positive or negative. If the latter, then the constant will of course be larger than either area or wheel record.

IMPROVED PRIMARY BATTERY.

By P. SELBY.

AMONG other things brought out here (Sydney, New South Wales) by me nearly four years ago was an *electric pen* apparatus with a Fuller bichromate battery. The difficulty of obtaining suitable cells and zincs for replacement caused me to seek some other form of cell by which the expense and internal resistance of porous pots could be avoided. After sundry experiments with a view to narrow the matter down, I arrived at a stoneware jar containing the usual bichromate potass solution plus sulphuric acid, a piece of thin platinum wire clothed with pure black India rubber, and a ⅛ inch tube cemented to the wire at an inch from the bottom. The spare inch of wire was then made into a flat spiral capable of picking up a small quantity of mercury (Fig. 1), the India rubber tube being simply for insulation, so that the platinum should not affect the result. On plunging this into the jar of solution a good current was produced for a short time; when withdrawn for examination, it was found that *part* of the mercury still adhered to the platinum wire, although action had ceased; a fresh dip of mercury restored the effect. On investigation I found that the mercury had been used with zinc, and was in fact *an amalgam*. The absence of zinc meant absence of effect. On this result a simple and effective cell was formed. (Fig. 2.) A small jar (2 oz. Liebig's extract of meat jar) was divided off by a *glass partition* cemented in with bicycle tire cement (more expensive than Chatterton's, but much stronger for grooveless partitions, jointing parchment paper cells for Leclanches, India rubber, gutta percha, shellac, and bitumen) reaching *nearly* to the bottom of jar; mercury is then poured in (dotted in Fig.) to form a "sealed joint" to separate the fluids; carbon on the one side of the partition (but *suspended* so as not to touch the surface of the mercury) in bichromate potass, sulphuric acid solution, and on the other side zinc standing in the mercury in *plain water* to assist in counterbalancing the bichromate fluid on the other side, so as to require less mercury to make a safe joint. Of course the jar is represented wider than is really the case, so as to prevent confusion in the sketch. I was led to this form by many circumstances, among others the peculiar way in which a zinc in bichromate battery was "undermined" where it was outwardly protected by a cement which resisted the action of the dilute acid solution in the porous pot.

For cheapness and handiness, glass tumblers or drinking glasses with what are known as *well bottoms* (Fig. 3) would make up very handy cells for experimental purposes.

Further experiments led to a "thistle tube" of glass arrangement, the tube (Fig. 4) being bent in a gas flame as shown, mercury placed therein, and copper wire being passed down the stem into the mercury. This is simply placed in a jar of solution containing the carbon, but the mercury must receive occasional replenishments of small pieces of sheet zinc, which readily dissolve in it. The thistle tube is convenient for lifting in and out, and when it can be lashed to a spring clothes peg clipped on the top of the jar.

But for permanent use a small shallow pot of earthenware (such as Needham's metal polish is sold in—Fig. 5) has a round zinc rod cemented in firmly, so as to form a means of lifting in a complete state out of the outer battery jar, mercury is then poured in to form a "water joint," a paraffin lamp chimney with a "crinkled" top (Fig. 6) is then inverted and passed down the zinc rod into the mercury and filled with *pure water* to counterbalance the pressure of the *surrounding* fluid (bichr. potass + ac. sulph., usual solution), in which stands the carbon.

Note.—This water remains purely free from any acidity for months, and by careful tests I find that the addition of sulphuric acid simply weakens the battery by setting up a "counter" current. In the "porous pot form" the acid seems quite necessary to lower the resistance of the fluid, but here it is different. Of course a preferable form to avoid risk of cement giving way would be to make the glass and the dish in one (in glass), with piercings to insure the continuity of the body of mercury in contact with the zinc and the bichrom. ac. fluid.

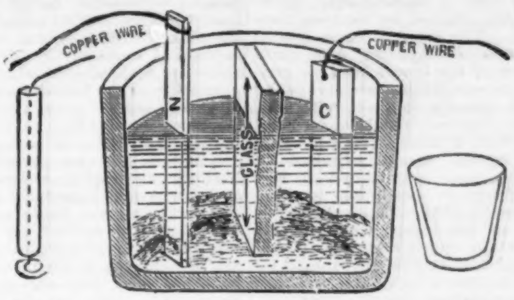


FIG. 1. FIG. 2. FIG. 3.

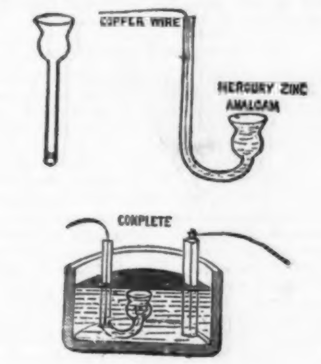
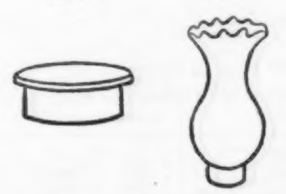
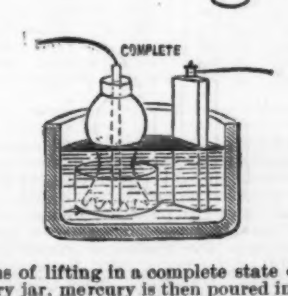


FIG. 4.

FIG. 5. FIG. 6.





The thistle tube arrangement I do not like, owing to having to supply the zinc, and the surface of mercury is too small, too, but the other arrangements I have tested for six months successfully.—*Elec. Review.*

[Concluded from SUPPLEMENT, No. 636, page 10160.]

THE POSITION AND PROSPECTS OF ELECTRICITY AS APPLIED TO ENGINEERING.*

By WILLIAM GEIPEL.

III.—ELECTRIC LIGHTING.

OF the four branches of electric engineering dealt with in this paper, electric lighting is the one which up to the present has received most attention, called forth the largest outlay of capital, and produced the most beneficial results, if not to so great extent in this as in other countries. Artificial illumination may be considered in the three aspects of comfort, convenience, and economy. As regards comfort, electric lighting proves itself superior to all other methods of illumination. For indoor lighting, the incandescent light may be utilized and toned down to suit almost any requirement. It may be brought near to any object requiring illumination, without occasioning the least inconvenience from heat or dazzle, or it may be far removed in the ceilings or cornices, without risk of fire or of injury to the decoration. In short, it can be used in any position or for any purpose of illumination for which gas, oil, or candles are available, and for a great many for which they are not available. For outside illumination and large inclosures, the arc light gives a brilliancy and cheerfulness altogether unattainable by any reasonable expenditure of gas or oil. The convenience of the electric light has caused it to be highly appreciated, when it is found that by the mere pressing of a button a light is instantly obtained, which can be shaded over in any manner, without danger of setting fire to the fabric forming the shade. It also does away with the constant cleaning of globes or trimming of lamps. In respect of economy, the electric light does not as yet hold out the same decided advantages that it does in the other two respects just considered. In incandescent lighting, the cost of distribution is still heavy, though by increasing the electromotive force and the efficiency of lamps it is being much reduced. In arc lighting, the difficulty of subdividing and of reducing the amount of light given by one arc lamp renders it expensive for general outdoor street illumination, as compared with the present low prices of gas and oil. For the lighting of main streets and railway stations, or other places where a concentrated light is required, the arc light is, beyond question, far cheaper than gas, and its cost per candle power is but a very small fraction of that of gas. As the use of electric lighting extends, the cost of working becomes reduced; installations which four years ago cost 4d. per arc lamp per hour are now costing only 2d. The chief saving has been in the items of carbons and attendance, though the increased efficiency and durability of the apparatus have also greatly contributed to the reduction. Four years ago 11 millimeter or 0·42 inch hard carbons cost 4d. per foot. They can now be obtained for 1¼d. per foot, or less than one-third. The following figures, supplied by the North British Railway, respecting the actual cost of working their electric lights at the Waverley station, Edinburgh, are interesting as showing how much cheaper it is becoming. The installation is worked by their own staff, and consists now of forty Brush arc lamps, supplied with a current of 10 amperes by a No. 8 Brush dynamo, which is driven by a semi-fixed engine.

July to December, 1884, *Thirty-three Arc Lamps*, 41,884 *Lamp Hours.*

	£	s.	d.
Wages	165	13	9
Repairs	47	2	6
Carbons	125	15	11
Coal	65	19	11
Oil, stores, etc.	27	15	0
Interest and depreciation at 10 per cent	52	2	2
Equal to 2·77d. per lamp hour.	£484	9	3

July to December, 1886, *Thirty-nine Arc Lamps*, 55,068 *Lamp Hours.*

	£	s.	d.
Wages	195	17	6
Repairs	78	9	6
Carbons	62	17	3
Coal	23	14	1
Oil, stores, etc.	8	15	2
Interest and depreciation	41	10	6
Equal to 1·79d. per lamp hour.	£411	4	0

In conjunction with these arc lamps, they are running 148 Brush Victoria incandescent lamps, distributed

* A paper recently read before the Institution of Mechanical Engineers, London.

in the refreshment and waiting rooms, and throughout the whole of the suburban station. For these the total number of lamp hours for the half year was 171,351, and the cost was £83 9s. 9d., including all contingencies, equal to 0·12d. per lamp hour. There were 118 lamps renewed, which shows an average life per lamp of 1,515 hours.

Local Conditions.—The cost of incandescent lighting is especially variable, and affected by the local conditions of the installation. The chief of these are (*a*) the average number of hours of lighting each lamp and (*b*) the average distance of the lamps from the generating station. Where the conditions are favorable, incandescent lighting can already compete with gas, and in a number of installations which have been superintended by the author, a large saving is being effected. The following figures, kindly supplied by Messrs. George Jager & Son, show that the yearly cost of lighting their sugar refinery at Leith has been reduced from £347 with gas to £204 with incandescent lamps. The average life of the lamps is about 1,400 hours each. The installation consists of 180 Brush Victoria lamps of 17 and 10 candle power, supplied by a self-regulating Victoria dynamo, which is driven off the shaft that drives the centrifugal drying machines. The dynamo has been running night and day since it was started two years ago without failure. It is started on the Monday morning, and runs continuously without stoppage till the following Saturday afternoon.

	£	s.	d.	£	s.	d.
Previous average cost of gas lighting per annum	332	13	4			
Part of plumbers' time..	15	0	0			
				347	13	4
Cost of Electric Light, May, 1886, to May, 1887.						
Lamp renewals	46	0	8			
Oil, waste, sundries	17	5	0			
Coal at 3 lb. per horse-power per hour, 40 tons at 6s.	12	0	0			
Repairs, including men's time attending dynamo	36	5	3			
Depreciation at 10 per cent.	33	16	0			
Gas consumed on Sundays, and when engine is standing	58	4	5			
				204	0	4
Saving per annum by electric lighting				£143	13	0

In the United States there is hardly a city or town of 20,000 inhabitants which has not a central station for arc or incandescent lamps, and many towns of 3,000 to 4,000 are supporting them also. On the Continent large central stations for electric lighting are already in operation in competition with gas; but there the price of gas is generally two or three times what it is in this country. If the power is to be generated by dynamos and used direct, the cost of distribution on a large scale will probably never be reduced as low as with the existing gas supply; seeing that an efficiency of 95 per cent. can now be obtained with the dynamo, and that steam engines are not likely to be materially improved. It is therefore in the lamps that improvement is to be looked for, by making them with a higher resistance and greater efficiency. The accompanying table V., which is an abbreviation of one previously constructed by the author, may be interesting here as showing how the economical sectional area of conductor and the economical loss of potential vary for the different conditions of amounts lost in interest and depreciation on the conductors, and in horse power wasted in overcoming the resistance of the conductors. The question of conductors is one which must be left to a very great extent at the discretion of the engineer, in view of what are likely to be the requirements of each individual case; but when the conditions have been settled, table V. is useful in showing at a glance the size and cost of the conductor, and the ensuing loss of potential.

Westinghouse company has already in America over 100,000 lamps at work on this system, although it is not yet so much as two years since they adopted it. Notwithstanding that the use of transformers enables a great saving in copper to be effected, more especially where the lamps are scattered, as in suburban districts, yet it is to be remembered that the insulation of underground conductors forms a very important item in their total cost. The installations already at work are all worked with overhead conductors, with the one exception at Eastbourne. So far as the author is aware, there are no practical data to establish the general applicability of the transformer system for the lighting of large and thickly populated towns where underground conductors may alone be tolerated. The loss owing to induction will also be vastly greater with underground conductors, however carefully installed. Secondary batteries charged in series by a high tension current and discharged in parallel circuit have been tried experimentally; but their practical application is not known to the author. At the same time, now that transformers are becoming more used, strenuous efforts are being made to introduce this system of secondary batteries; and if it can once be demonstrated to be economical, there can be little doubt that it would have a large field of application. Its great merit is, of course, the reduction of risk of the light failing. It should be borne in mind by electric light companies that the supply of incandescent lamps is not to be their only source of revenue; but, as already pointed out, the supply of current should be of such a nature that it may be employed for as many purposes as possible. By the use of efficient boilers and engines and properly constructed continuous current dynamos, a central station can be so constructed as to be no nuisance whatever, provided proper precaution be taken in selecting the site.

In large towns it will not be necessary to extend the conductors very far before a demand will be met with sufficient for occupying an engine large enough to be economical. Above a certain size the cost of working a steam engine becomes practically constant for any increase in size; so that, instead of working from one large central station over a very large area, it is found better to work from smaller stations over smaller areas. The cost of attendance will thereby be increased to only a small extent, because one man cannot fire more than two boilers; therefore when more boilers are required, it is preferable to work them at another station with another fireman. At Leamington, an extensive central station is now at work, and the cost of the undertaking is about £30,000. The Bradford corporation have recently voted a sum of £15,000 for erecting a central station in their town. Both of these are instances of direct supply, without transformers or secondary batteries.

IV.—ELECTRIC METALLURGY.

This branch of electrical engineering bids fair to become speedily of the highest interest to engineers. The electro-chemical separation of ores on a commercial scale by the electric furnace has but recently been put to the test, chiefly in obtaining aluminum from corundum, its richest ore. Sir William Siemens first turned his attention to the subject, but his death occurred before he had perfected his invention. It was taken up by Messrs. Cowles, who, with the assistance of Professor Mabery, have devised a furnace in which by the passage of powerful currents the refractory ore is successfully reduced. The furnace is built of fire brick, and lined with powdered charcoal to withstand the intense heat. It is in the form of a box, 5 feet long, 12 inches wide, and 15 inches deep. Current is conducted through the walls and into the ore by means of a number of carbon rods, 3 inches in diameter, and from 2 to 3 feet long.

The positive and negative carbons are introduced from opposite ends and nearly meet in the center. The ore, mixed with charcoal and granulated copper, is put in so as completely to surround and cover the carbon. The furnace thus charged is closed with a layer of charcoal and a lid lined with fire brick; without the protection of some such refractory material as charcoal the intense heat causes the fire bricks to run. When the furnace is ready, the current, with an electromotive force of 50 volts, is turned on, and is gradually increased up to some thousands of amperes. In a few minutes the metal is melted around the electrodes. And these are then moved farther apart, until the current passes through the entire charge, and the whole is in a molten condition; the corundum becomes gradually deoxidized, the aluminum combining with the copper, while the oxygen with the carbon escapes as carbonic oxide; about five hours suffice to complete the reduction. Current is supplied by large Brush dynamos. This machine was specially constructed for the work, and is capable of giving out 300,000 watts, or over 400 electrical horse power. Its weight is nearly 10 tons; 5,424 lb. of copper are wound on the field magnets, while the armature has 825 lb. of copper on it. Works already in operation at Lockport, U. S., have a capacity of 6,000 lb. per day; and the cost of the aluminum bronze so made is expected to be less than 1s. 8d. per lb., while Mr. Cowles anticipates the price being reduced to 8d. per lb. Works have also been started at Stoke-on-Trent, where a 500 horse power dynamo has been fixed for generating the current; the potential is 60 volts.

TABLE V.—ELECTRIC CONDUCTORS—SECTIONAL AREA, COST, AND POTENTIAL FALL.

Cost of Conductors	£100 per ton = 10·71 d. per lb.			£150 per ton = 16·07 d. per lb.			£200 per ton = 21·43 d. per lb.			£250 per ton = 26·79 d. per lb.		
Cost per year per electrical H. P.	Area per 100 Amperes.	Cost per 100 Yards.	Potential Fall per 100 Yards.	Area per 100 Amperes.	Cost per 100 Yards.	Potential Fall per 100 Yards.	Area per 100 Amperes.	Cost per 100 Yards.	Potential Fall per 100 Yards.	Area per 100 Amperes.	Cost per 100 Yards.	Potential Fall per 100 Yds.
£	Sq. inch.	£	Volts.	Sq. inch.	£	Volts.	Sq. inch.	£	Volts.	Sq. inch.	£	Volts.
½	0·04576	2·378	5·3231	0·03736	2·912	6·5194	0·03235	3·362	7·5279	0·02894	3·759	8·4165
1	0·06471	3·362	3·764	0·05283	4·118	4·6099	0·04576	4·755	5·3231	0·04093	5·316	5·9514
10	0·20463	10·633	1·1903	0·16708	13·023	1·4578	0·1447	15·037	1·6833	0·12942	16·812	1·882
20	0·28939	15·037	0·8417	0·23629	18·417	1·0308	0·20463	21·266	1·1903	0·18303	23·776	1·3308
30	0·35443	18·417	0·6872	0·28939	22·556	0·8417	0·25062	26·046	0·9718	0·22416	29·12	1·0866
40	0 40926	21·266	0·5951	0·33416	26·046	0·7289	0·28939	30·075	0·8417	0·25884	33·625	0·941

Transformers.—These are at present receiving a large amount of attention. By their means, small high tension currents of electricity sent from a distant generating station along a small conductor, with a comparatively small percentage of loss, can then be converted into large low tension currents for the supply of ordinary incandescent lamps. In some arrangements of these transformers the loss in conversion is not more than 5 per cent. Unfortunately, the alternating system, which has thus far been adopted, cannot be used with satisfaction for driving motors doing practical work or for charging storage batteries. The continuous current transformer has certainly the advantage in respect to the supply of power and to the charging of storage batteries; but it is a question whether the disadvantage of having to keep it continually in motion will enable it in town lighting to compete with the alternate current transformer. The latter is employed in the Grosvenor Gallery central station in London. Some idea of its importance may be formed from the fact that the

Another electric furnace has been devised by Dr. Kleiner, of Zurich, in which cryolite, a double fluoride of sodium and aluminum, is similarly treated. When it is remembered that the metal aluminum, in addition to many other good qualities, possesses great strength, with only one-third the weight of iron, the importance of obtaining it at a reasonable cost will be readily appreciated; it would undoubtedly cause a great revolution in engineering construction. The process of welding by electricity, introduced by Professor Elihu Thomson, is similarly based upon the passage of a powerful current between two electrodes. In this case the two pieces of metal to be welded form the electrodes; they are brought together into close contact, and as soon as the current is sent through the joint, its resistance causes intense heat until the weld is perfectly completed. The process is almost instantaneous, and the heating occurs only at the joint; tempered steel can be thus welded without in the least affecting its hardness.

Another plan of electric welding has been introduced at St. Petersburg, by Dr. Bernardos, in which the heat necessary for fusion is caused by an arc. The current is conducted to the weld by means of a carbon rod, which is connected by a flexible cable with the positive terminal of a dynamo or battery, while the metal to be welded is connected with the negative terminal. The action of the arc set up by the flow of current from the carbon to the metal may be likened to that of the blowpipe flame, except that the heating is more intense and sudden, and is therefore more local. The reducing action brought to bear on the metal keeps it clean and unoxidized.

Mr. Fearfield said that armatures often wore down quickly. He had four running at his works, and had put down eight or nine in other works, and he found that the renewals ran from £4 up to even £10 per armature. It was caused by the wear and tear of the phosphor-bronze, which, if oiled too much, fired from the brushes. The electric current cut the barrel of the commutator irregularly, and it had to be put in the lathe again. This applied not only to the transmission of power, but also to electric lighting. The author had referred to a 4 inch belt, but had not stated the speed, and a 4 inch belt would practically carry almost anything. The belt might have been strained or might not, or might have been carrying a large or a small amount of power. With regard to the cost of electric lighting, he had found that over a period of four years it had cost him what amounted to 2s. 1d. per thousand cubic feet, as against 2s. 4d., which was the price of the gas supplied by the Nottingham Corporation. To show the necessity of attention to the armatures, he might mention that at the Colonial Exhibition an engineer from the Brush company was in charge of an installation. He was not sufficiently careful about the insulation of the arc lamps, and he found that he had a splendid ground current. Armature after armature had to be put in, and the wires were immediately burned. There was too much speed on the engine, so that they could not get even the voltage they required to drive the lamps. It was, therefore, necessary to train the men as electricians as well as engineers. It had been stated that 600 volts was about the safest tension to which the electric current could be worked on tram cars. Many years ago 10 lb. over atmospheric pressure was considered excessive in a boiler, but they were now accustomed to 140 or 160 lb. pressure. In the same way, he thought it would eventually be found possible to carry 10,000 volts on a wire safely.

EXPERIMENTAL OPTICS.

LORD RAYLEIGH, in his recent lectures at the Royal Institution upon the above subject, demonstrated the laws of refraction when light passes to and from a denser medium by means of a short drum-shaped vessel with glass ends, half filled with water made milky, while the upper half was filled with air made opalescent with burnt brown paper smoke, since he opined that some of those present might object to the smell of cigar smoke. The bending of a thin ribbon of light from the electric lamp was thus made visible as it entered or left the water, so that at the same time the principle of reversibility in optics was demonstrated. The law of refraction, he said, was first demonstrated by Snell, and was sufficiently accurate for practical purposes.

In dealing with the phenomena of reflection he remarked that although the phrase "total reflection" is convenient, it does not apply accurately to the bending back of light inside a right-angled prism, because in such case the phenomena is not reflection at all, for reflection is ordinarily understood to apply to the bending back of light at the surfaces of two media, where a portion of the light is absorbed; reflection requires an abrupt transition between one medium and another. He considered that there is a certain amount of advantage in shortsightedness; some maps and railway time tables appear to be printed for the special benefit of shortsighted persons.

As age advances, the sight of such persons sometimes improves, and sometimes does not do so. Another defect in eyesight sometimes existing is that vision is good in a horizontal and not in a vertical direction. In such cases glasses with spherical curvature are not good, and cylindrical lenses usually have to be applied as the remedy. He, however, proved that by sloping a spherical lens he could lengthen the image of a circular spot of light either in a vertical or horizontal direction, and that at the same time the position of the whole lens had to be shifted backward or forward to obtain the best focus. A method of detecting this defect in vision is to draw some parallel lines upon a piece of paper, then turn the piece of paper slowly round in its own plane, and watch whether the lines are seen more distinctly when the paper is in one position than when it is in another; if so, it is a proof that cylindrical lenses are needed, and the experimenter had better go to an oculist.

Lord Rayleigh then spoke of the telescope, saying that the simplest way of ascertaining the magnifying power at one of those instruments is to look through it with one eye at a brick house or brick wall, and at the same time to view the same object with the other eye; with a little skill the two images may be made to overlap, and by counting the relative number of bricks in the two images then occupying the same apparent length, the

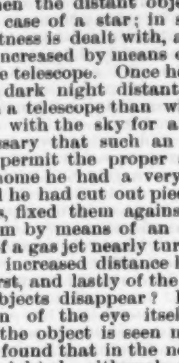
power of the instrument is revealed. The magnifying power is in the exact ratio of the width of the parallel beam of light before it enters the object glass and its width where it enters the pupil of the eye, provided the beam is then still parallel.

A bright object appears to have the same brightness at whatever distance it may be from the eye of the observer; if we were a great deal nearer to the sun, the sun would appear no brighter than at present, but a great deal larger; a telescope does not make an object appear brighter for the same reason; it brings it apparently nearer by magnification. An exception to this rule is when the distant object is exceedingly small, as in the case of a star; in such instances the aggregate brightness is dealt with, and the brightness of the object is increased by means of the light-collecting power of the telescope. Once he could not understand why on a dark night distant objects could be seen longer with a telescope than without it, as in the case of a steeple with the sky for a background. He thought it necessary that such an object should be rather large to permit the proper application of the principle. At home he had a very dark room, with black walls, and he had cut out pieces of white paper of different sizes, fixed them against one of the walls, and viewed them by means of an exceedingly feeble light, like that of a gas jet nearly turned out. He then found that with increased distance he lost sight of the small objects first, and lastly of the large ones. Why did the small objects disappear? In consequence of the imperfection of the eye itself, so that in the "nearly dark" the object is seen mixed with its environment. He found that in the nearly dark he was distinctly shortsighted, although in the light his vision was all right, and he believed this defect of eyesight to be more general than is usually supposed; the lens which helped him most in the nearly dark hindered his vision in the light.

The lecturer next spoke of Newton's great discovery of the composition of white light as revealed by the spectrum, and demonstrated the various points by experiment; he said that for some years after its publication scarcely any one in the world believed in Newton's discovery; some of those who tried to repeat his experiments failed, perhaps because lenses and prisms were bad in those days. White light seemed to objectors to be obviously such a simple thing in itself that to advocate its colored composition appeared to complicate the subject.

APPARATUS FOR FRACTIONAL DISTILLATION UNDER REDUCED PRESSURE.

L. MEYER is the inventor of the apparatus shown here and described in the *Chemiker Berichte*. It contains no cocks for the distillate to pass through, so that no contamination with lubricating material takes place. In A the end of the condenser tube is secured by a perforated cork; to B is connected in like manner



the flask which is to receive the distillate. The tube, C, is connected above to the apparatus by an air tight perforated cork, so that it can be raised or lowered. Its lower end is ground so as to fit tightly the opening leading from the vessel into the tube, B. Both tubes at D and D' are connected by tubing to a T tube which by tubing is connected to an air pump. The two-way cocks, E and E', can put the inside of the apparatus in communication with the air pump or with the atmosphere. When distillation is going on, both cocks preserve communication between the apparatus and the air pump. The tube, C, is drawn up a little, so that the distillate runs into the flask. If the flask is to be changed, B is sealed off by depressing the tube, C, air is admitted by E, while through E' exhaustion continues, and the distillate collects above the ground joint in B. When the new flask is put in place, by very slow turning of the cock, E, it is brought into communication with the air pump, and finally, when the exhaustion is complete, the tube, C, is drawn up again.

SALINE FODDER PLANTS.

By R. W. EMERSON MACIVOR, F.I.C., F.R.G.S., F.C.S., Etc.

IN some of the inland pastoral areas of Australia, where the soils and waters are more or less saline in character, the ground is covered, not with grass, but for most part with "scrubby" vegetation consisting of several varieties of the *Atriplex* family, and known as "salt bush," upon which sheep not only thrive wonderfully well, but experience an immunity from diseases of all kinds unknown in even the richest grass districts. A few years ago Mr. J. Everett, an extensive sheep owner in Victoria and New South Wales, sent me some specimens of two kinds of salt bush (*Atriplex speciosus* and *A. campanulata*) growing on one of his newly acquired properties, with the request that I should report upon their nutritive qualities. The following are my analyses so far as I had time or occasion to carry them. No. 1 is the average of two analyses, and No. 2 of four analyses of thoroughly dry samples.

	No. 1. A. campanulata.	No. 2. A. speciosus.
Carbohydrates	43·16	42·25
Fiber	12·68	15·48
Albuminoids	14·35	13·70
Fat	2·21	2·20
Ash	27·60	26·61
	100·00	100·26

The ashes (less CO_2) had the following centesimal composition:

	No. 1.	No. 2.
K_2O	19·17	22·43
Na_2O	34·75	38·92
MgO	7·05	6·12
CaO	16·40	13·26
Fe_2O_3	1·55	1·40
P_2O_5	4·62	3·96
SO_3	3·29	2·44
SiO_2	2·93	4·14
Cl (Cl_2—O=55)	10·25	7·28

The percentage of chloride of sodium in the ash of different samples of each variety varies very much, being sometimes only two or three, and occasionally as high as thirty-eight or even forty.

The most remarkable peculiarity of these plants is that they contain more than twice the average quantity of ash found in any other known plants.

Their high value as fodder for sheep is due to the proportion of carbonaceous and albuminous nutrients they contain, and also to the chlorides and potash, which serve to aid digestion and the production of "suint."—*Chem. News.*

[Continued from SUPPLEMENT, No. 636, page 10166.]

THE CHEMISTRY OF SUBSTANCES TAKING PART IN PUTREFACTION AND ANTISEPSIS.*

By JOHN M. THOMSON, F.R.S.E., Sec. C.S., Demonstrator of Chemistry, King's College, London.

III.

HAVING now examined the more important chemical properties of the products of putrefactive decomposition, we come to the consideration of the various substances employed as counteracting agents to such decomposition. The action of these substances is described under the term "disinfection," which may be defined as a process or processes which will avert, counteract, or ultimately destroy products either by physical or chemical means.

At the same time, while we may endeavor to give an absolutely strict definition of the term, you will see that this definition can never quite cover, or in itself explain, the very many methods by which the process of disinfection may be carried out. Until within recent years, the term "disinfectants" has been almost universally employed to designate the agents employed in counteracting these putrefactive changes; but lately, and more especially in medicine, the term "antiseptics" (*anti*, against, and *sepo*, I make rotten) has been introduced, and I have, therefore, in my title taken the liberty of employing the word "antisepsis" instead of disinfection as the term to indicate the action of these several methods.

Our next duty, after explaining the meaning of the term, is to classify if possible the various methods in which these antiseptic actions may be carried out, and to arrange to a certain extent the various antiseptic agents in groups. This classification may be of a varied nature, but it appears to me that for all useful purposes we may divide the methods by which the actions are produced into the following classes:

A.—Mechanical and Physical Methods:
Ventilation; exclusion of air; dryness; extremes of heat or cold; absorption.
B.—Chemical Methods:
Action of antiputrescent or antiseptic substances.

You will see that any division we make must be purely arbitrary, and that great difficulty will always exist in arranging the methods separately, as certain of the changes mentioned will naturally overlap each other, more especially among those of a mechanical and physical nature.

When we examine the substances which act according to these different methods, we find that a further subdivision is necessary, and excluding in this what may be termed purely mechanical actions, such as ventilation, washing, brushing, etc., we may classify the agents as follows:

Group I.—*Absorbents, deodorizers—*
a. Physical absorbents; dry earth; charcoal.
b. Chemical absorbents; metallic oxides; metallic salts.
Group II.—*Antiseptics, chemical substances—*
a. Inorganic.
b. Organic.

Should it be required, this second group may be again divided into such substances as hinder only temporarily the putrefactive decomposition and those which absolutely neutralize and destroy the action of the virus.

Exclusion of air is undoubtedly a means of preventing putrefactive changes from commencing, but how long such a state of security may remain is somewhat difficult to fix. Where air is absolutely excluded, or only comes in contact with the material liable to change in a thoroughly filtered or purified condition, as we saw in the series of flasks in my first lecture, then we may expect no change to take place. The condition of exclusion of air, however, points more to the exclusion of the contagion inducing the change than to the fact that absolute exhaustion of the air would prevent such a change when once it had been induced. Still at the same time it retards such changes to a very considerable extent, and a common instance of such a delayed change is to be found in the preservation of logs of wood in peat bogs, where they will lie for great lengths of time in a comparatively unchanged condition, when they are entirely enveloped by moderately dry peat. We may also mention the common household plan adopted for the preservation of eggs, namely, of covering them, when freshly laid, with a film of butter, and then leaving them in some material, such as milk of lime or fine sawdust, till wanted for use. It must be understood however, that such methods are purely retarders, and that change will probably take place sooner or later.

Closely allied to this preventive measure we have another condition, the "absence of moisture." Perfect dryness acts as a strong hinderance to decay, as may be seen in the length of time perfectly dry wood will last without undergoing the process of rotting; and there is little doubt that some of the modern methods for the treatment of fæcal matter depend as much on the drying of the material as they do on mixing it with a porous absorbent. This we shall have to refer to further on.

The influence of moisture in assisting decomposition may be seen on examining two jars of sawdust, one perfectly dry and the other slightly moistened from time to time. On introducing a lighted taper into the jar containing the damp sawdust, you see that as the taper descends it burns less brilliantly, and when it reaches close above the sawdust, finally goes out. This is due to the production of carbon dioxide gas in the very slow decay of the moist wood.

EXTREMES OF COLD AND HEAT.

We have seen at the commencement of the course that a certain temperature was necessary to carry on the fermentive change, but at the time I also told you that, should the temperature either rise above or sink below certain limits, such changes become at once arrested. Such is also the case with the changes of putrefaction, which apparently become arrested when the temperature is reduced below the freezing point of water. To show you this, I must content myself with the fermentation of sugar by yeast, which I described to you in my first lecture.

We have here the same flask used on that occasion with a solution of sugar containing yeast in an active state of fermentation. On repeating our former experiment, and transferring some of this to a similar flask containing ice, you observe that the evolution of gas is checked and finally ceases. The practical application of these facts is to be found in the modern method of preserving fish, meat, etc., by cold, so that they may be carried to very great distances. It is to be observed here that this process is most effective when carried out in conjunction with the abstraction of moisture, the material to be kept remaining in a more perfect and better condition for household purposes when preserved in dry air at a temperature below 0° C. than when kept, as the plan originally was, in contact with ice. The presence of moisture, however, if the temperature be sufficiently low, does not prevent the preservation of animal matter for great lengths of time in a more or less perfect condition; and in proof of this, I need only remind you of the well known case of the mammoth found embedded in a block of ice, in which it had remained preserved for many hundreds of years.

Correspondingly, the effect of an extreme in the other direction exercises exactly the same effect, a rise in temperature producing a hindering or cessation of the putrefactive change. We have, as illustrations of such action, the preservation of meat and fruit in closely fitting tins, the contents of which before closing the tin having been raised to the temperature of boiling water, if not farther. The sterilizing, as it is termed, of different materials employed in scientific experiments is effected by heating them to an extremely high temperature, almost to that of charring, and keeping them for some time at that temperature. In connection with this it is right to mention that for the perfect destruction of certain of the lower organisms which initiate the putrefactive change, it is necessary that the heat be applied more than once, to insure the final destruction of the virus producing the change.

Actual combustion, entailing as it does the final conversion of organic matter into its simplest products, must be regarded as the most effectual method of disinfection, and history shows us that it is one which has been employed from a very early date. The practice of surrounding infected districts with a ring of fires, and thus effectually preventing the contagion from passing, has often been employed in the case of epidemics in highly populated districts, and there is little doubt that the great fire in London was one of the agents most effectual in arresting the spread of the plague in that time.

The well known methods for the preservation of meat and fruit by inclosing them in tins, and hermetically sealing them when the contents are at the boiling temperature, depend upon the destruction of the exciting cause at that temperature, as well as the exclusion of air from the vessels themselves. That these methods have not been universally successful was found in the case of certain contracts entered into at the time of the Crimean war, when an enormous amount of tinned provisions were supplied to the army in a very advanced state of decomposition.

PROCESSES OF ABSORPTION.

Absorption by Charcoal.—Charcoal, from its porosity, may be regarded as one of the most powerful absorbents which we possess, and from this property and the comparative ease with which it can be prepared is of great value both for the absorption of gaseous as well as liquid products of decomposition.

We shall see that in certain cases the gaseous products not only undergo absorption, but are at the same time decomposed. This is markedly the case in hydric sulphide, but for our present purpose I prefer to regard this absorptive action as of a purely physical nature.

The charcoal employed is generally one of two kinds, (*a*) vegetable or (*b*) animal. The first variety may be prepared either by the partial combustion of wood, in the older method by arranging it in heaps covered with turf and sand, or by the more modern method of distilling the wood in closed vessels or retorts, whereby the products of distillation, such as wood tar, water, naphtha, etc., are obtained, as well as the porous charcoal. Animal charcoal is obtained by the partial combustion of bones, and differs from wood charcoal in containing a much larger quantity of mineral matter, apparently making it much more valuable as an absorptive medium.

The porosity of charcoal can be readily demonstrated to you by placing a piece of wood charcoal, weighted with lead, in this cylinder, which is filled with tap water, and arranging it under a bell jar in the air pump. On giving a few strokes to the pump you perceive little bubbles forming on the surface of the charcoal, these gradually increasing in number till, as the exhaustion proceeds, the tap water begins to effervesce like soda water from the escape of the bubbles of air originally contained in the pores of the charcoal.

Another striking illustration of its capability to absorb gases may be seen on allowing some small pieces of recently calcined charcoal to pass up into dry ammonia gas in a tube standing over mercury. You

* Three lectures before the Society of Arts, London, 1887.—*From the Journal of the Society.*

perceive that the moment I introduce the piece of charcoal into the tube, absorption at once begins, the charcoal absorbing a volume of gas very much larger than its own volume. On removing the charcoal from the mercury, the ammonia gas will escape from it again very readily, and its presence can be easily perceived by its odor.

The absorption of gases by charcoal varies according to the nature of the material from which it is prepared, a dense variety of wood like boxwood or cocoanut generally yielding the most absorptive variety of charcoal. This absorption has been examined by Saussure, Angus Smith, and Hunter, and the following table shows you roughly the coefficients of absorption for certain gases:

Absorption of Gases by Charcoal.

One volume of charcoal absorbs:

90	vols. of	ammonia gas.
85	"	hydrochloric acid gas.
65	"	sulphur dioxide gas.
55	"	hydric sulphide gas.
40	"	nitrous oxide gas.
35	"	carbon dioxide gas.
9·4	"	carbon monoxide gas.
9·2	"	oxygen gas.
6·5	"	nitrogen gas.
1·25	"	hydrogen gas.

The general point to be observed in examining such absorption is the fact that the more readily the gas undergoes liquefaction, so does its absorption by the charcoal increase, pointing to a partial condensation of the gases in the pores of the charcoal, such gases as oxygen, hydrogen, and nitrogen, which are liquefied only with difficulty, having a very small coefficient of absorption.

As I mentioned to you at an earlier period of my lectures, some gases are not only absorbed by the charcoal, but appear also to undergo a certain amount of decomposition from the air already held in its pores. This is to be seen very markedly with gases such as hydric sulphide, or with those derived from the putrefaction of material rich in nitrogen. In the former case the gas becomes converted into H_2O and SO_2 in a manner analogous to its decomposition during incomplete combustion. After some time the sulphur dioxide undergoes oxidation in the presence of moisture, resulting in the formation of sulphuric acid (H_2SO_4). Free sulphur can also be extracted from the charcoal by proper solvents at a certain stage of the absorption. In the case of ammonia this gas apparently becomes gradually converted into ammonium nitrite and nitrate.

Boxes containing charcoal in a suitable state of division have been used for the filtration of noxious gases from drains; and respirators of the same nature have been introduced for wearing over the nose and mouth. Those of you wishing to test the efficiency of charcoal as an absorbent of disagreeable odors may do so by examining this jar which I have on the lecture table. It contains a piece of animal matter in an advanced stage of decomposition, which is covered with a layer of charcoal about three inches in depth, and you will perceive on smelling above the charcoal that no offensive odor can be detected; on removing the little plug, however, in the lower part of the chamber, you will at once detect the putrid odor.

Recently calcined charcoal may be most advantageously employed when thickly strewn over decaying matter—placed in trays as a ventilator in air passages, or employed for the packing of fish, game, or meat, for transmission from one place to another.

Charcoal may be employed for the absorption of liquid and solid substances as well as gases, and the color of logwood and indigo may be readily removed from solutions of these substances by shaking them with wood or animal charcoal. The decolorizing power of wood charcoal is much inferior to that of bone charcoal; which is attributed to the circumstance that the latter, when examined, is found to contain much less carbon than the former, but a considerable quantity of mineral salts, as calcium, phosphate, etc., the presence of which separates the particles of carbon over a much larger area, and so presents a much larger surface for the absorption of the coloring matters. Animal charcoal is employed in sugar refining for the decolorization of the brown sirup before its evaporation to obtain the white crystallized sugar.

The employment of charcoal as an absorbent for noxious gases and other kinds of filtration was first prominently brought forward in this country by the late Dr. Stenhouse, Mr. Turnbull, and Dr. Angus Smith.

In certain cases, materials other than charcoal may be employed as absorbents, and the methods for the treatment of excreta, originally devised by Mr. Moule, depend upon the employment of dry powders or earth. For the proper carrying out of the process of disinfection with such bodies, certain rules must be observed, the neglect of which diminishes to a great extent the value of the method. In the case of dry powders or earth, these must be brought in contact with the material as soon as possible, must be intimately mixed with it, and must be in a perfectly dry condition, so as fully to carry out their absorbing action.

Chemical Absorbents.—Another class of substances which we may regard as acting as absorbents are mineral substances such as quicklime (CaO) and certain metallic salts, most notably lead acetate [$Pb(C_2H_3O_2)_2$], bismuth nitrate [$Bi(NO_3)_3$], zinc chloride ($Zn\,Cl_2$), and ferrous sulphate ($Fe\,SO_4$).

These substances evidently act by absorbing the noxious gases, forming with them compounds which fix the gas and remove it from the surrounding air. Quicklime readily absorbs the carbon dioxide, becoming converted into carbonate, and lead acetate, or bismuth nitrate will absorb the hydric sulphide, forming sulphides; while ferrous sulphate may be employed as an absorbent for such gases as ammonia or nitric oxide. Such substances are of especial value as absorbents in sick rooms, etc.

The researches of Dr. Frankland have shown that in the case of iron salts they apparently exercise a specially destructive action on bacteria.

PROPERTIES OF CERTAIN INORGANIC DISINFECTANTS.

In examining the disinfecting substances belonging to or derived from inorganic sources, I will endeavor to arrange them as much as possible in the following order. But I wish it to be understood that no strict chemical classification or grouping of these substances can be at all well made.

a. Certain gaseous substances and the bodies from which they are derived, as—
- Chlorine, bromine.
- Hypochlorites.
- Oxygen, ozone, hydrogen peroxide.
- Potassium permanganate.
- Sulphurous acid gas.

b. Strong mineral acids, sulphuric acid.
- Fumigations by nitrous and nitric acids.
- Boracic acid, borax.
- Arsenious acid.

c. Certain metallic salts.
- Chlorides of zinc, aluminum, and iron.
- Sulphates of zinc, iron, and copper.

Such antiputrescent substances probably exert their influence in the following different ways:

1. They may abstract water from the fermentable substances, and so exercise a drying or mummifying action.
2. They may form compounds which are less liable to undergo decomposition.
3. They may decompose the ferment producing the change.
4. They may deoxidize the ferment; or remove the oxygen from the surrounding air.
5. They may kill the fungi, or the germs, exciting the putrefactive change.

Certain of the antiseptic substances may carry out their action according to one of these methods only, while others may act according to two or more of the methods specified.

Chlorine gas has been long employed as a disinfectant, having been first introduced by Guyton de Morveau about one hundred years ago. This element, with its associates, bromine and iodine, are extremely active agents, both in combining with other elementary substances and in decomposing certain organic compounds to which, as we have seen, many of these putrefactive substances belong. They are all obtained more or less directly from sea water, where they exist as chlorides, bromides, or iodides of certain metals; from which they may be obtained by the action of sulphuric acid in presence of binoxide of manganese.

You will readily perceive the energy with which chlorine acts upon other substances if I bring some finely powdered antimony in contact with the gas, which I do under this bell jar, when you see the antimony catching fire and burning, as its powder falls into the bottle of chlorine gas. Almost all the metals unite in the same way, if in a finely divided condition, forming chlorides, and this property must be kept in mind during the disinfection of a room by chlorine gas, when all metal articles must be removed or covered up.

It unites directly in the cold with phosphorus, as you will perceive on my taking a small piece of that substance in this deflagrating spoon, and plunging it into a bottle of chlorine. The phosphorus at once catches fire, forming thick fumes of phosphorus chloride.

Chlorine gas unites directly with many non-metallic elements, more especially with hydrogen, and it is upon this tendency to combine with that element that the chief applications of chlorine depend. The two gases will unite directly when brought together in daylight; but they may also be made to combine when chlorine is brought in contact with an organic body rich in hydrogen.

You will recollect that I showed you in a former lecture the decomposition of olefiant gas (C_2H_4) by chlorine, and a similar decomposition may be seen if we employ another hydrocarbon turpentine ($C_{10}H_{16}$) still richer in hydrogen. On smearing a little spirit of turpentine on filter paper, and introducing it into a bottle of the gas, energetic action takes place, with an enormous deposit of free carbon.

This energetic action of chlorine causes it to unite with the hydrogen in water, liberating oxygen, and it is to this property of acting as an indirect oxidizing agent that its bleaching and disinfecting properties are attributed. Many vegetable coloring matters of great permanency, such as indigo, undergo an oxidizing action in the presence of moist chlorine, the indigo being first oxidized into isatin, and then by excess of chlorine converted into chlorisatin.

$$\underbrace{C_8H_5NO}_{\text{Indigo.}} + H_2O + Cl_2 = \underbrace{C_8H_5NO_2}_{\text{Isatin.}} + 2HCl.$$

$$C_8H_5NO_2 + Cl_2 = \underbrace{C_8H_4Cl\,NO_2}_{\text{Chlorization.}} + H\,Cl.$$

From this you will perceive that the chlorine must be in the presence of moisture to effect the action; the indigo being oxidized to isatin at the expense of the oxygen in the water. In fact, dry chlorine will not bleach, as is shown us in this vessel, where some crimson paper is suspended in a jar of the dry gas, remaining in it quite unchanged.

For the purposes of disinfection, either free chlorine or its solution in water is somewhat inconvenient, and it has become the custom to employ for this purpose a substance known to you as "bleaching powder;" most probably a mixture of calcium hypochlorite with calcium oxychloride [$Ca(Cl\,O)_2 + Ca_2\,O_2\,Cl_2$]. This powder, or its solution, on treatment with dilute acids, liberates chlorine gas in a manner more suitable for practical purposes. The solution of the powder itself does not bleach litmus, as you see on adding it to this jar, but a few drops of dilute sulphuric acid at once causes the disappearance of the color, owing to the liberation of chlorine. Such gases as hydric sulphide, ammonia, and substances similarly constituted are at once broken up by chlorine gas.

The properties of bromine and of iodine vapor appear to act in a manner similar to chlorine, but in the case of iodine the action is somewhat weaker. Both these elements impart very distinct colors to certain solvents which readily dissolve them. Thus on shaking an aqueous solution of bromine with ether, we obtain a brilliant yellow color in the ethereal layer, while iodine may be extracted from its solution by carbon disulphide, which, being heavier than water, sinks to the bottom colored a deep purple by the absorbed iodine.

Bromine must evidently be regarded as a stronger agent than iodine, and apparently in its disinfecting action stands intermediate between chlorine and iodine, just as it does in its ordinary chemical relations to these substances. Of late it has been introduced in a convenient form for deodorizing and disinfecting as "Bromodine," a mixture of a bromide and bromate, of which I have a small quantity in this jar. This mixture in a perfectly dry state is mixed with potassium bisulphate also in the same condition; as long as these powders remain perfectly dry they may be kept together unchanged, but on moistening the mixture with water, action at once commences, with the evolution of bromine.

For the disinfection of an ordinary room by these agents, the room should be cleared if possible of all metallic articles, those which cannot be removed being covered to as great extent as possible. The chlorine may be evolved by treating a mixture of common salt and manganese binoxide with sulphuric acid. The room should be thoroughly closed and kept in this condition for some time. After sufficient time has elapsed for the chlorine to permeate thoroughly through the whole space, the room may be opened and ventilated with a current of fresh air.*

Oxygen, Ozone.—The next gaseous disinfectant I would bring before your notice is oxygen gas, and its condensed modification, ozone. There is no doubt that oxygen must be regarded as the great natural purifier, and that a proper state of sanitation depends almost entirely on a large and pure supply of pure air. It occupies a peculiar position in the processes of putrefaction; a certain amount being necessary for the production or continuance of the changes, but an excess counteracting and destroying the action. Its anti-putrescent action is evidently that of increasing the vital energy of the different growths to such an extent that they become destroyed by rapid oxidation. In the case of such substances as hydric sulphide, we have seen how this oxidation, taking place in the pores of the charcoal, finally leads to decomposition.

Ozone (O_3) and Hydrogen Peroxide (H_2O_2).—As the supply of oxygen in the free condition must of necessity be very large to perform a thorough disinfecting action, we are induced to look for such agents as will supply us with that substance in a condensed and active condition. These are to be found in the two substances, ozone and hydrogen peroxide, the former of which may be regarded as oxygen in a modified and concentrated form. Ozone exists free in the atmosphere, especially near the sea or in the open country, and possesses a peculiar odor from which it receives its name. It is formed by the silent discharge of electricity, by the electrolytic decomposition of water, and by the slow oxidation of such easily oxidized substances as ether and phosphorus.

Its properties are like those of oxygen, only in a much more energetic form; and it is from the energy with which it unites with potassium when combined with iodine that we are enabled to test for it and show its presence.

I have here what is termed a Siemens ozonizing apparatus, by means of which, on attaching the tinfoil with which it is coated to a Ruhmkorff coil, and passing through the apparatus a current of dry oxygen, you will presently perceive a very distinct odor of ozone. That the oxygen has undergone change we can readily see by bringing in front of the apparatus some white paper, on which I have written with a mixture of starch paste and potassium iodide. The energy of the combination between the potassium and the ozone liberates the iodine from the compound, and this at once gives with the starch the characteristic blue color. In this change we find that the oxygen has undergone condensation, and that a contraction of $\frac{1}{3}$ in the volume of the oxygen has taken place; the ozone, however, is never obtained in its production unmixed with oxygen.

Its production by the slow oxidation of phosphorus in the presence of water you see going on before you in these bottles, in which we have some half immersed sticks of phosphorus. On bringing some iodized starch paper into the mouth of the bottle, you at once see the liberation of the iodine by the ozone.

From the presence of ozone in ordinary air, and from the activity of its properties, it is natural that it should have attracted attention as a possibly natural disinfectant; and this supposition is strengthened by the fact that none is found in crowded places, where there are many reducing agents capable of using it up, and that when such do not exist, as in open country, ozone is apparently always present. The quantity, however, in which it is found is very minute, and has been approximately fixed by M. Honzeau at $\frac{1}{700000}$ of the volume of air. It is in larger quantities in summer than in winter. A small amount of evidence has been brought forward of the production of ozone in the oxygen which is given off by plants, but it is somewhat conflicting; it is found, however, in the evaporation of certain essential oils, and the following are extracts from experiments conducted on this point by Dr. Angus Smith:

Comparative quantities of Ozone given off from certain essences.

	After 48 hours.	After 72 hours.
Essential oil of orange	9	10
Essence of terebenthine	7	9
" cumin	2	2
Cresylic acid	2	2

The determinations were made with standard iodized papers.

Hydrogen peroxide in not of so great importance, but is somewhat allied to ozone in its oxidizing properties. It has sometimes received the name of "oxygenated water." When this substance is brought in contact with decomposing matter, the putrefactive odor disappears, and ozone, or ozonized oxygen, is liberated. Its power, however, rapidly diminishes with the loss of ozone.

The properties of hydrogen peroxide are very interesting from a chemical point of view. It undergoes decomposition when brought in contact with certain metals, such as gold, silver, and platinum, which have no direct attraction for oxygen, and certain oxides also effect its decomposition without themselves undergoing change. The oxidizing power of hydrogen peroxide may be readily seen by bringing it in contact with chromic acid. On mixing together a very dilute solution of potassium bichromate with a little dilute

* Since the above was written, Mr. W. Thompson, at the meeting of the British Association at Manchester, has proposed the employment of certain compounds of fluorine as antiseptic and preservative agents, and has described the very satisfactory results obtained by the use of these substances.

sulphuric acid, and adding a drop or two of hydrogen peroxide, a beautiful blue color, due to the formation of perchromic acid, is produced. If the solution be now shaken with ether, the blue color is extracted and made more permanent, permitting us to detect by this means very small quantities of hydrogen peroxide.

Dr. Angus Smith, in 1869, proposed this substance as a disinfecting agent, but its expense at that time prevented its employment in practice.

In the changes of hydrogen peroxide I have shown you that that substance alone has undergone decomposition; but if we bring it in contact with potassium permanganate ($K_2Mn_2O_8$), itself a substance rich in oxygen, both undergo decomposition, large quantities of oxygen being given off. This is seen when I add a few drops of dilute H_2O_2 to this solution of the permanganate acidified with sulphuric acid, when the red color of the permanganate is at once destroyed, and bubbles of oxygen gas are given off, which reignite a spill plunged into the gas.

Potassium Permanganate—Condy's Fluid.—The efficacy of this substance depends upon the facility with which it parts with its oxygen, and the amount and purity of the gas which is obtained from it. Many organic substances are oxdized by it, more especially those arising from putrescent changes.

The ease with which organic matter may be oxidized is readily shown you by taking a sample of impure water, such as I have here, and adding to that some dilute Condy's fluid acidified with sulphuric acid. The color at once disappears, showing the reduction of the permanganate. As the potassium permanganate in its reduction loses a definite quantity of oxygen if a standard quantity be used in the experiment, then the quantity of oxygen lost is known, and from this the quantity of organic matter oxidized may be approximately calculated. The oxidizing power of this substance is very well shown in its action on glycerine, which when brought in contact with solid permanganate undergoes direct combustion, burning at the expense of the oxygen derived from the permanganate. Oxygen may also be obtained from it directly by heating, and you perceive that an incandescent spill of wood is at once rekindled by the oxygen derived from heating the permanganate I have in this tube.

The preparation of potassium permanganate can be best shown to you by heating caustic potash (KHO) and manganese dioxide together in a silver dish. By this means potassium manganate, a green substance, is formed, but on pouring this into a large volume of water, and adding to it an acid like nitric acid, we have the green color changed at once to the brilliant crimson of the permanganate. The green fluid of Condy is the sodium manganate (Na_2MnO_4).

Sulphur Dioxide, or Sulphurous Acid Gas (SO_2).—This substance has been known and employed as a disinfectant for a very great length of time, both from the strong antiseptic properties which it possesses and the ease with which large volumes of the gas may be obtained. The method for its preparation most suitable for the purposes of disinfection is by the combustion of elementary sulphur in a suitable supply of air or oxygen; or by the combustion of some substance rich in sulphur, such as we have in carbon disulphide (CS_2).

Sulphur dioxide, like chlorine, possesses strong bleaching properties, but, unlike that gas, it acts by abstracting oxygen from the material with which it is brought into contact; that is, it acts by reduction. Its bleaching properties may be seen by burning some flour of sulphur under a bell jar in which a bunch of violets has been suspended, when you see that the color of the flowers very rapidly undergoes a bleaching action, ultimately becoming perfectly white. Its action is, however, in this case, somewhat weak, as the color may be recovered by washing the flowers in a weak solution of ammonia, when the hues of the flowers are restored, but not in their original beauty.

The antiseptic action of sulphurous acid is best seen by pouring a little of the solution of the gas, in water, into a flask with fermenting sugar, when the evolution of the CO_2 very soon ceases. Certain of its salts or sulphites are also employed for this purpose. The gas is also used for the fumigation of clothes and rooms, to kill vegetable and animal growth, and this antiseptic property is valuable for the sulphurizing of wine and beer casks, to prevent any growth of a ferment likely to destroy the fresh liquor.

In its antiseptic action, sulphur dioxide evidently acts as a reducing agent, depriving the surrounding material of oxygen and becoming converted into sulphuric acid. This oxidation is readily seen when we pass a current of dry oxygen gas mixed with sulphur dioxide over some heated platinized asbestos, when you perceive that the transparent gases are converted into dense white fumes. In this action we have the direct conversion of SO_2 into SO_3 by the addition of an atom of oxygen. This process is now carried out on the large scale for the production of the solid sulphur trioxide. A somewhat peculiar action is observed when gaseous SO_2 is brought in contact with H_2S gas, in which apparently both undergo decomposition with the formation of water and sulphur. The reaction is probably not so simple as this in reality, some of the higher or thionic acids being formed at the same time.

The well known disinfecting powder termed "MacDougall's disinfectant" is composed of a mixture of calcium sulphite with carbolic acid, a substance which we shall have to examine later on. Another variety is a mixture of sodium sulphite with calcium carbolate.

Sulphurous acid and the gas form an extremely good disinfecting agent for domestic purposes, in certain instances more convenient to employ than chlorine, the manufacture of which in an ordinary room is attended with a certain amount of inconvenience. With SO_2, on the other hand, which can be produced in large volumes by simply placing some flour of sulphur in an iron vessel and igniting it with a red hot coal, the sulphur burns perfectly quietly, and no further heat need be applied.

Sulphuric Acid (H_2SO_4).—This substance is produced, as we have seen, by the oxidation of sulphur dioxide, and may be regarded as one of the strongest of the destructive agents. It acts most distinctly as a germicide, possessing, like the other mineral acids, hydrochloric and nitric acids, a most corrosive action on the material coming in contact with it.

From this property of acting so strongly on organic substances the concentrated acid has been employed on a large scale for the protection of wooden stakes intended to be fixed in the ground or under water. This protection is produced through a partial charring of the wood by the acid, as I can show you with this vessel containing some wood shavings. On pouring the sulphuric acid on the shavings, they at once become coated with a protecting layer of inert carbon, which protects them from all ordinary action.

When brought in contact with certain carbonaceous substances, which contain also hydrogen and oxygen in the proportions in which they exist in water, such as sugar ($C_{12}H_{22}O_{11}$) and wood fiber ($C_6H_{10}O_5$), it exercises a dehydrating action, leaving the carbon in its elementary condion. This is most markedly seen on pouring some of the strong acid on some thick sirup of sugar, when the whole mass undergoes charring, frothing up and evolving clouds of steam.

The sulphuric acid not only chars the surface of the wood, but apparently exerts some action on the tissue in the interior in a manner similar to that seen in the formation of parchment paper. Its solvent action on pure cellulose is also very marked, as may be seen on adding some pure cotton to the concentrated acid, when you perceive that it gradually passes into solution. The corrosive action is seen very markedly in the clearing up of coagulated albumen, of which I have some in this glass beaker. On adding the sulphuric acid, even in a very dilute condition, the liquid becomes perfectly clear, the albumen having been entirely decomposed. The antiputrescent characters of this acid, as well as of hydrochloric and nitric acids, have been examined, more especially by Dr. J. Dougall and the late Professor Baxter. Alkaline or neutral liquids left to themselves become charged with mycelium and bacteria, and frequently acquire a fetid odor. If, however, another portion of the fresh liquid be treated with acid in sufficient quantity to render it distinctly acid, the fermentation is slow and without the production of bacteria; should the acid be in very distinct quantities, all growth is stopped, and no putrid odor is produced.

THE SPANISH NATIONAL LOTTERY—NEW MECHANICAL APPARATUS FOR THROWING THE NUMBERS.

THE first distribution, by the new system of illumination, of the national Spanish lottery took place on the 20th of January last. At one end of the saloon where the proceedings took place there were five large globes of copper in a row, separated by artistic supports, and the branches formed handsome arches. Above each globe there were ten balls of equal size carrying numbers, and they were strung upon a rod. The balls that represented units were orange colored; those for the tens, yellow; those for the hundreds, blue; those for the thousands, rose color; and those for the tens of thousands, white. The five globes were connected with an underground mechanism which imparted to them a rapid rotary motion.

The director-general of state rents presided, assisted by functionaries who determined the rules. One of these, the fiscal of the tribunal of royal accounts, publicly inspected the balls and certified to their correctness. The president then struck a bell, and all the balls fell at the same time into their respective globes, which were afterward locked and were then made to rotate upon their axes. The extraction of the unit balls was begun by a boy who turned the key of the globe, and the first ball descended through an arm of copper to the receiver, which was a small crystal vase. Another boy then took the ball and read in a loud voice the number which it bore, and then carried it to the fiscal, who repeated the number. The same boy then took the ball and carried it to a box prepared for the purpose and containing a rod to receive the unit balls. This ball contained the figure 1.

The same operation was repeated in respect to the other four globes, and the five balls were collected in corresponding order in the box, which was then shut and locked with two keys, one for the director of rents and the other for the fiscal of accounts, and the box was left in public view. The boy then read the gross number thus formed, which was 02·341. The proceedings were continued by extracting the balls from the other globes one by one, a boy reading in a loud voice successively all the numbers, and they were exposed to view in a special apparatus and strung in the order of units upon the ten rods, black balls occupying the five places corresponding to the five balls of the numbers of the drawing.

The whole apparatus is very well arranged, and had been constructed by Mr. Roche from plans designed by Mr. Garcia Paton, engineer.—*La Ilustracion Espanola.*

THE SPANISH NATIONAL LOTTERY—NEW MECHANICAL APPARATUS FOR THROWING THE NUMBERS.

A NORTHWEST PASSAGE.

To the Editor of the Scientific American:

The object of this communication is not only to call attention to what the writer considers the only practical solution of the "Northwest Passage" problem, but to present a few facts bearing on the climatic causes which operate to produce a more rigorous climate in the eastern parts of North America than that of the "Pacific slope."

The Pacific slope is protected by a range of lofty mountains from polar winds; the eastern portion of the continent is not; therefore we can never control *this* cause of difference, but there is *another* cause of difference which can and ought to be abolished, or at least ameliorated.

While the "Japan current" warms the "Pacific slope," Arctic currents are allowed to flood our eastern shores as far south as Newfoundland, and Hudson's Bay is converted into an Arctic sea by ice water poured through Fury and Hecla Strait.

The remedy I propose is to close Smith's Sound, Jones Sound, and the three channels separating North Devon from Melville Island.

If this proved sufficient—but I think it would not—to induce that part of the Gulf Stream which now passes up the western shore of Greenland as far as Davis Strait to seek Baffin's Bay, Gulf of Boothia and Hudson's Bay, the work could be discontinued; but if it should be driven back by a current through Banks Strait, that strait also should be closed.

The Gulf Stream would then flush even Melville Sound itself, and return, by way of Fury and Hecla Strait, from Lancaster Sound, through Hudson's Bay, warming up the polar winds which are such a dread in winter.

Such an undertaking would require a vast amount of money, but it ought to be undertaken jointly by the Dominion and the United States.

There is plenty of rock on both sides of those channels which could be utilized. The rock should be dumped in the deepest parts, on the line selected for dike, first; and as the water grows shallower the current will slacken, and danger from floating icebergs will thus be overcome; but if the rock were dumped in from the sides, the current would increase in velocity, bringing heavy icebergs to tear down the dike. Besides, as the square of the current's velocity increased, so would its power to wash away all the finer materials, dirt, sand, etc., increase.

When this work is accomplished, there will be no current setting this way from the Arctic, and the waters which now render a tract of land one fourth as large as the United States practically a barren wilderness will be discharged through the channels of the

North Atlantic, and the barren territory mentioned will be capable of sustaining thirty millions of the human race.

Let us see if such is not the fact. In Europe the line which marks the northern limit of barley, rye, and oats crosses Scandinavia about latitude 69, or as far north as King William's Land. Where is this line in North America? At the lower end of James Bay, or over one thousand two hundred miles too far south. *Over this vast tract grain ought to grow and civilization flourish.*

In the United States there is nearly as bad a condition compared with what may be.

In Europe we find the orange flourishing as far north as 45°, or the latitude of the northern part of Vermont, and on our own Pacific slope as far north as Philadelphia.

When this work (which can be completed in 15 years at most, were one half the energy necessary to carry on some more ignoble work, a great war for instance, applied in its furtherance) shall have been accomplished, we shall have solved the Northwest Passage problem, and vessels will be able, at all seasons, to navigate Lancaster Sound and Barrow Strait, Melville Sound, Prince of Wales Strait, McClintock Channel, Franklin Strait, Victoria Strait, Dease Strait, and Dolphin and Union Strait. G. A. K.

Shunk, Pa.

THE VALLEY OF MOGOK—RUBY MINES DISTRICT, UPPER BURMA.

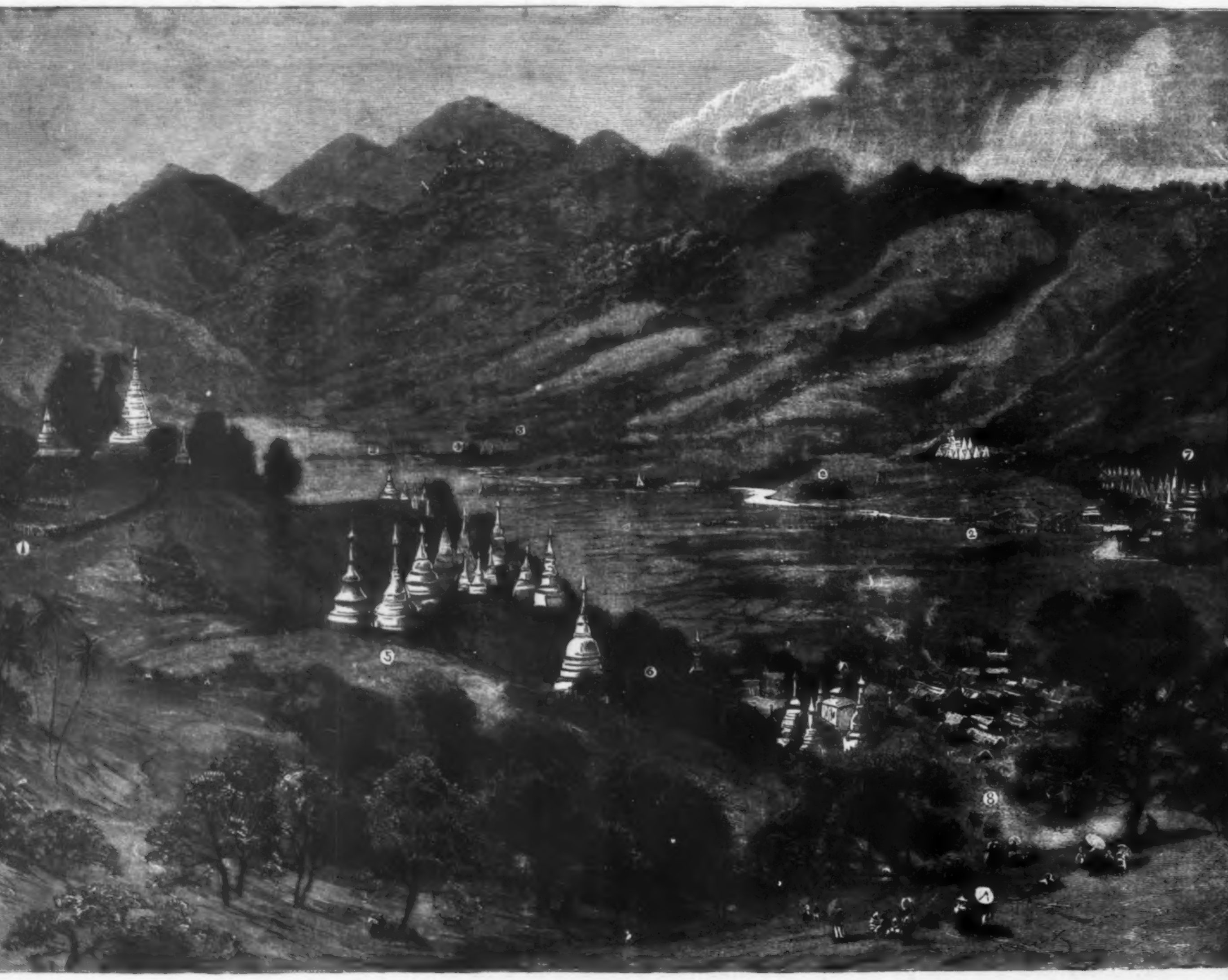
THIS engraving, which is from a sketch by an officer lately commanding the military police battalion, represents the whole of the valley of the Mogok, which is situated fifty-one miles from the east bank of the Irrawaddy, and roughly seventy-five miles north of Mandalay. The altitude of the town of Mogok is 4,200 feet.

Mogok is nothing more than a large village. The inhabitants are extremely wealthy, the wages for daily labor being one rupee (1*s*. 4*d*.) in English money.

The valley is about one and a half miles long and three-quarters of a mile broad, the slopes penning it in being covered in the spring with a richly colored flora consisting of rhododendrons, peach blossom, wild raspberries, and briar roses.

Owing to the vacillation displayed by the home government for a whole year, this field, which is teeming with precious stones, lies practically untouched, for though local miners are working in the old and primitive style, no income has been derived. When we say no income, the amount realized by the end of June was under 3,500 rupees, or scarcely 250*l*. The royalty placed upon the sale of rubies is thirty per cent., and, as the local government has not as yet taken any precautions to prevent smuggling, all the valuable stones are carried off by the local dealers, chiefly Panthays and Shans. A stone was lately sold in Mandalay for a sum of 8,000 rupees. This fact was unknown to the officers of the government until long after the sale.

There are at work upward of seventy-eight mines which produce nothing, whereas in King Theebaw's time the outturn was the monopoly of the crown.—*London Graphic.*



1. The military police stockade, garrisoned by 100 rank and file, which is the standing garrison of Mogok. This stockade was erected by the 43d Goorkhas when the mines were first seized.
2. Small mines now being worked, known as the Lon-Dwin, (Lon = round, Dwin = a wall). These mines are usually twenty or thirty feet deep. They of course rapidly fill with water at night, consequently the work of excavation is delayed each morning for several hours, owing to the primitive method of drawing out the water, which is done by means of lowering a bucket attached to a bamboo weighted at the other end.
3. Mines at work—these are known as Hmaw-Dwins (a cutting). Some of the best stones are found in these mines, which are merely cuttings in the side of the hill. The water used for "washing" is brought, in some cases many miles, in small drains along the sides of the hills from the higher plateau.
4. Buddhist monastery.
5. Pagodas erected during the lifetime of wealthy miners who have passed away, in order to perpetuate their memory. Some of these are entirely covered with gold leaf, and glisten brilliantly in the sun.
6. Monastery of the "Sadaw," or Bishop.
7. The China village, inhabited by the Chinese merchants.
8. The town of Mogok.

THE RUBY MINES, VALLEY OF MOGOK, UPPER BURMA.

COLOR IN PLANTS.

AT a recent meeting of the Edinburgh Botanical Society, Mr. Sewell read a paper in which he showed that more or less intense color always accompanies the various degrees of imperfect vegetation. Spring and autumn tints come under the same explanation as flower colors, in that there is in each case a using up of previously obtained material, not a predominance of the constructive elements throughout the cells.

Coloring in connection with reproduction may first be noticed among the cryptogams, where the reproductive parts of the plant are yellow or white, their energy being spent otherwise than in producing chlorophyl for a vegetative function.

Mr. Spenser and Mr. Grant Allen have both pointed out that "incipient floral color is present in all imperfectly developed shoots," or "might be expected to appear in flowers because of their low constructive energy." Evidence of this was seen in caulerpa, were, though yellow when in drier, less nutritive habitats, it became green when grown in water—a more nutritive condition. Foliage plants, as croton, or such plants as *Arum maculatum*, have their color more intense when pot-bound, or growing in less nutritive places; green takes the place of the color when grown under more vegetative conditions, as, for instance, when newly repotted by the florist.

It is where growth is locally restricted, as in the petioles of *Primula sinensis*, as on secreting surfaces of pitcher plants or drosera, or as in honey glands, that color tends to appear. A similar explanation accounts for the red tips of daisy and pyrethrum; for the appearance of new colors at the apex of the petals, as it is in the apex rather than the base, or among the disk flowers that growth has most certainly ceased. We may similarly account of the predominately white color of winter flowers, because at that time of year all growth is sluggish, there is less actively destructive change from the primary yellow color. On the contrary, Alpine flowers, growing where there is an open and sunny exposure, favoring high destructive change, are notably brilliant. Certainly there are not a greater number of insects in Alpine than in lowland regions; nor is the explanation of white rather than red winter flowers to be found in the absence of insects which would select reds at that time, as has been suggested.

Changes of color during the life of the flower, as seen in *Convolvulus minor* or *Myosotis versicolor*, are but gradations of the natural series of changes observable with more or less distinctness, as it occurs in greater or less degree in nearly all flowers. Such changes occur especially just before death. They are very noticeably caused by altered climatic conditions, as for instance where a cold and damp winter has been observed to be productive of white varieties or a hot dry summer of red ones. That white varieties of plants normally red or blue are products of changed or weakened constitution is shown in the fact that such plants as white calluna or erica may be distinguished by the lighter green of their foliage, as well as by their flowers.

To explain such color variations as those of *Polygala vulgaris*, we do not need to agree with Dr. Taylor, who considers that the three colors of *Anemone patens*, for instance, "are three kinds of bait," which nature has provided that the plant may be more certain of attracting insects. We may understand such varieties, if not of present origination, yet to have originated under different conditions of growth, which favored a more or less actively destructive constitution in the petals.

A labiate, not unlike *Salvia horminum*, common in Thuringia, shows all the stages of this series of color change in single plants. The flowers are yellow, while the bracts which terminate the floral axis are colored either yellow, red, or purple, the purple being produced at the extemity of the axis whenever present, just at the place where, from checking the growth and exposure to the sun's rays, the character of the cell contents would be influenced most acutely.

Indeed, if we bear in mind these facts, agreeing with the assertion made by Mr. Spencer that floral colors appear at the termination of the axis, we must differ from him in his further conclusions, that "this color tends to fade away, and is only prevented from disappearing by the action of natural selection."*

More or less intense color appearing wherever vegetation is checked, we must expect accumulation of color in flowers as a necessary consequence of the reduction which is there taking place; it does not matter how this reduction is mainly brought about, whether by use, environment, or natural selection.

We see also that colors need not be held to be due to slow indefinite variations, the cause of which remains unknown; it may be a very sudden variation brought about by climatic conditions, which sudden variations

* "Principles of Biology," vol. ii., p. 260.

are far more likely to be noticed by insects than are very gradual changes of tint.

It does not need that we regard flower color as existing alone by virtue of the benefit it confers upon insects, any more than we allow older biologists to regard it as produced because of its moral effect upon mankind. It is the natural outcome of the tendency toward perfection in the reproductive part of the plant. It is a correlation necessitated by the lessened vegetation, and though undoubtedly of use to insects, which check or quicken the tendency to color in one case or another, they have only taken advantage of the tendency, which cannot thus be said to have resulted solely on their account and by their selection.—*The Gardeners' Chronicle.*

A LARGE CALIFORNIAN GRAPE VINE.

THE two accompanying engravings, from photographs, represent the lower and upper parts of a grape vine now existing at Montecito, Los Angeles County, California, and belonging to Mr. Albert Magee. The vine is but thirty years old, and already covers an area of 900 square feet. Its present yield is five tons of grapes, and its circumference at the earth is forty-six inches. Near by, at Carpentaria, there is another vine almost like it. Both in time will become genuine vegetable curiosities.

In 1887, says Mr. Charles Joly, from information obtained by Mr. Wetmore, the wine production of California was but 16,000,000 gallons. Last year it was 18,000,000 gallons, but would have amounted to 30,000,000 had it not been for frosts and the dropping of the fruit, which destroyed half the crop.

Despite this, despite the old and new diseases which besiege the vine, it still remains the most remunerative plant to cultivate, and in California, Algeria, and Australia, as in France, Spain, and Italy, every one is endeavoring to enlarge his vineyard. To make the vine grow is a relatively easy matter when the climate favors it; what is more difficult is the manufacture of wine—the œnological science that our compatriots have acquired after many years of observation—and the selection of vine stocks according to soil and climate. In this there is much to learn and observe.

In a note published in 1884 upon the nineteenth session of the American Pomological Society, Mr. Joly gave a sketch of an old vine existing at Montecito, near Santa Barbara. This vine, which covered a space of 10,000 square feet, and which produced from 10,000 to 12,000 lb. of grapes annually, was cut down in order that it might be shown at the centennial exhibition at Philadelphia in 1876. It was a variety called the "Mission," on account of its having been imported by the first Spanish missionaries, who colonized the Pacific coast very long before the arrival of Americans from the East. The mission grape is now almost everywhere neglected, and has been replaced by new varieties much superior in quality, which already amount to more than two hundred in number, where formerly scarcely anything but the Isabella or Catawba was known. Who knows whether the United States, after importing the best plants of their gardens from France and Belgium, and after sending us their phylloxera-proof vines and their early peaches (as the Amsden and Alexander), will not in turn send us in the future other varieties of fruits that will enrich our present collections?

In England, where the grape is much cultivated under glass, we may cite, alongside of the example presented in the United States, some remarkable specimens of grapevines. We may mention particularly that of Hampton Court, which last year bore 1,500 bunches, and that of Cumberland Lodge, at Frogmore, which yields nearly an equal product. Some varieties produce monstrous bunches, weighing from 20 to 25 pounds. According to the *Gardeners' Chronicle*, the most remarkable one was exhibited in September, 1875, at Edinburgh. It weighed 20 pounds and 4 ounces.

After our mention of these foreign wonders, we shall add that to him who is interested in the improved culture of the vine, and especially the preservation of the grape, Thomery, near Fontainebleau, is always the most interesting point to visit, especially if the grounds of Mr. E. Salomon, one of the most skillful viticulturists that exist, can be seen. Here the Chasselas is cultivated over an area of 250 acres, surrounded by walls 10 feet in height and nearly 120 miles in length, giving the village a very peculiar aspect, like that of Montreuil, near Paris, for the culture of peaches.

A well cared for espalier produces on an average about half a pound of Chasselas grapes to the superficial foot. It costs about one hundred and fifty dollars per acre for the culture; but the product is worth from $700 to $800, according to the price of grapes, which varies from one to four and five cents a pound, according as the fruit is sold in October, March, or April.—*La Nature.*

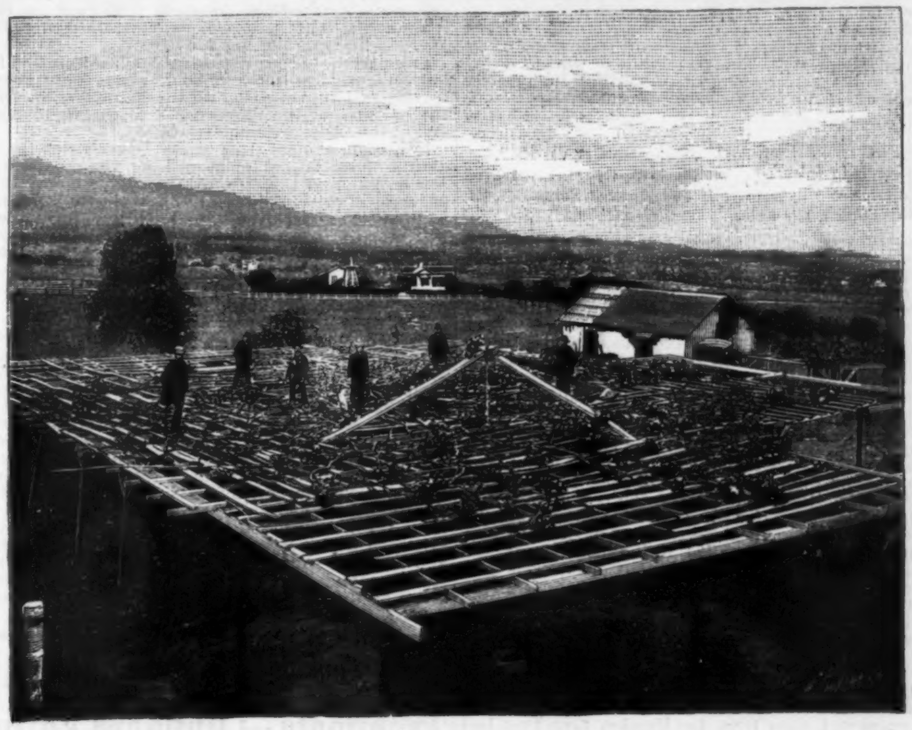


FIG. 2.—UPPER PART OF THE SAME VINE.

FIG. 1.—TRUNK OF A LARGE CALIFORNIAN GRAPEVINE.

MECHANICAL DENTISTRY.

By Dr. E. E. SHATTUCK, Kansas City, Mo.

No branch of dental practice requires more skill and judgment than that of the construction of artificial dentures. It is the duty of every dentist to become so dexterous in this branch as to be able to supply his patients with artificial teeth which may be worn without the slightest discomfort, and so closely resemble the natural ones as to be readily mistaken for them.

The utility of artificial teeth depends upon their proper construction and direct application. Perfect mechanism is not the sole element of success, generally it is not the most essential one; we must have a knowledge of the anatomy and physiology of the mouth—its pathological condition—if we expect to become skilled in dental prosthesis.

We must know when to use gold or some other materials, when to secure a piece by clasp bands or simple adaptation; also the proper time for its insertion. Accurate impressions are indispensable with atmospheric pressure. In the construction of every kind of artificial plates, we must remove all roots, or teeth, that are diseased, which will not yield to treatment.

All tissue in contact with the base plate should be in a healthy condition. As all alveolar ridges and palatine arches are of unequal density, we must therefore make a thorough examination of every part we wish to modelize to ascertain the relative softness and hardness.

The mouth should be rinsed with water previous to taking the impression. The most accurate impressions can be taken with plaster of Paris, but in deep arches wax should always be used first in the impression cup to copy the roof of the mouth. Remove, and trim the wax as much as desired; then fill with plaster and insert; press the rear of the cup up first, forcing the contents to the front of the mouth. In this way there will be no trouble from the plaster causing choking or nausea.

Never remove an impression until the plaster will break without crushing.

After the model has been taken from the impression, it should be scraped more or less, to correspond with the softness of the alveolar ridge and the palatine arch.

If there is only a small part of the roof hard, scrape the impression, instead of the model, at that point.

In all cases the plate should be in contact with the parts, but with slight relief of pressure over the hard portions. If this is not done, you will have an imperfect fitting plate.

A great many dentists have formed the erroneous idea that it is necessary to construct the plate with an air chamber, to secure its adhesion to the mouth, and that the tenacity is according to the depth of the cavity. This is a great mistake. There is no form of space cavity, or air chamber, that gives such firmness as absolute contact over the entire surface.

It is true the base with an air chamber when first introduced will adhere more readily than without, as long as the cavity acts in the retention of the plate, but it eventually draws the membrane into the space. The plate is then held only by contact.

If the air chamber is over a certain depth, it will cause the mucous membrane to become diseased. Every day's experience furnishes abundant proof of this fact.

If the space is not filled with membrane, after the plate has been worn a few days, it shows imperfect adaptation.

Next in importance to accuracy of the impression is correctness of articulation. This must be perfect. The teeth, if possible, should be set well under the alveolar ridge. If they are set outside, it is difficult to retain the best fitting plate during mastication.

The lower teeth should strike those on the upper jaw, both sides, at the same instant, with the exception of the last molars, which should just clear. This matter should never be overlooked.

Unless judgment, science, and art are exercised in constructing the work, from the taking of the impression till its completion, a total failure may be expected; or, at least, the plate will never be worn with satisfaction.

The firmness with which plates can be made to adhere to the mouth is wonderful, if made correctly. The work of nature can never be equaled by artificial teeth, but it is surprising how near they can be made to resemble them in looks and usefulness. The human teeth are so liable to decay that few persons reach adult age without losing some of these valuable members. As there will always be mechanical work for the profession, we must so perfect ourselves in this branch that we may be able to surmount every difficulty that may be presented to us. We must know what kind of material to use for a base when gold and porcelain crowns or bridge work are suitable. Crowning and bridge work are the most useful, if constructed rightly, to take the place of the natural teeth.

Many other useless roots can be crowned with gold or porcelain, and are far better than teeth with large fillings. By bridging from one tooth or root to another, we can insert teeth, where they have been extracted, that will perform the service of the natural ones, preferable to partial plates.

Crowns and bridge work, as constructed by some of the profession, are filthy and injurious to the health. We must have a knowledge of how they are to be constructed, if we perform the operation, and wish to become skilled in mechanical dentistry.

Notwithstanding the high state of excellence to which prosthetic dentistry has arrived, at no previous time was there so much injury inflicted by artificial teeth as at present, resulting solely from an incorrect application.

The construction of artificial plates is performed by every one who makes any pretence to dentistry. Unfortunately, it is but little understood by a great many. The readiness with which they can be made, and cheapness of material, has helped forward a style of practice in the highest degree detrimental to the profession.

A dentist who properly respects himself or his patrons should not be guilty of performing such work as we see nearly every day. This poor grade of work is owing largely to the better operators discarding the practice of mechanical dentistry.—*Archives of Dentistry.*

THE ETIOLOGY OF SCARLET FEVER.

By E. Klein, M.D., F.R.S., Lecturer on General Anatomy and Physiology at the Medical School of St. Bartholomew's Hospital, London.*

The investigation the results of which I now record was commenced at the end of December, 1885. It arose out of an inquiry into the prevalence of scarlatina in different quarters of London, undertaken by the medical department of the local government board as a part of its business of investigating local epidemics. That inquiry had demonstrated milk from a farm at Hendon as the cause of the scarlatina, and had adduced strong circumstantial evidence that the scarlatina had been distributed, not in the whole, but in sections of the Hendon milk, and further that the ability of the sections of milk service to convey the disease had been related to a malady affecting particular cows. This evidence against particular cows at the Hendon farm could not and did not aim at furnishing direct and definite proof of the connection of this cow disease with scarlet fever of man, for the inductive methods usually employed by the medical department of the local government board when applied to inquiries about epidemic spread of scarlatina can for obvious reasons yield but circumstantial evidence.

As on various former occasions, so also on this, the medical department sought to put the above conclusions to the test of scientific experiment. This task was delegated to me by the board. The first part of this work has been published in the recently issued volume of the reports of the medical officer of the local government board for 1885–86. I have therein shown that the suspected cows from the Hendon farm that had been made the object of special study showed besides a skin disease—consisting in ulcers on the udder and teats, and in sores and scurfy patches and loss of hair on different parts of the skin—also general disease of the viscera, notably the lungs, liver, spleen, and kidney, which resembled the disease of these organs in acute cases of human scarlatina.

I have further shown that the diseased tissues of the ulcers on the teats and udder produced on inoculation into the skin of calves a similar local disease, which in its incubation and general anatomical characters proved identical with the ulceration of the cow; and further, that from the ulcers of the cow a species of micrococcus was isolated by cultivation in artificial nutritive media, which micro-organism in its mode of growth on nutritive gelatine, on Agar-Agar mixture, on blood serum, in broth, and in milk, proved very peculiar and different from other species of micrococci hitherto examined. With such cultivation of the micrococcus I have produced by subcutaneous inoculation in calves a disease which in its cutaneous and visceral lesions (lung, liver, spleen, and kidney) bears a very close resemblance both to the disease that we observed in the Hendon cows as well as to human scarlatina.

The second part of the work, carried out during 1886–87, for the medical department, had for its object to investigate whether or no the disease human scarlatina is associated with the identical micrococcus, and whether this, if obtainable from the human subject, is capable of producing in the bovine species the same disease as was observed in the Hendon cows and in the calves experimented upon from the latter source. The definite and clear proof that this is really the case has now been obtained, and the evidence I now bring to the notice of the Royal Society.

On examining acute cases of human scarlatina—for which opportunity I owe great thanks to Dr. Sweeting, the medical superintendent of the Fulham Fever Hospital—I soon ascertained the fact that there is present in the blood of the general circulation a species of micrococcus which on cultivation in nutritive gelatine, Agar-Agar mixture, blood serum, and other media, proved to be in every respect identical with that obtained from the Hendon cows.

Out of eleven acute cases of scarlet fever examined in this direction, four yielded positive results; three were acute cases between the third and sixth day of illness, with high fever temperature; and the fourth was a case of death from scarlatina on the sixth day. In all these four cases several drops of blood were used, after the customary methods and under the required precautions for establishing cultivations in a series of tubes containing sterilized nutritive gelatine, and generally only a very small number of these tubes revealed after an incubation of several days one or two colonies of the micrococcus. This shows that the micrococci were present in the blood in but small numbers.

Having ascertained the identity in morphological and cultural respects of the micrococcus of the blood of human scarlatina with the organism obtained from the Hendon cows, the action of the cultivations of both these sets of micrococci was then tested on animals and the results compared. It was found that mice—wild mice better than tame ones—after inoculation or after feeding, became affected in exactly the same manner, no matter whether the one set of cultivations or the other was used.

The great majority of these animals died after between seven and twenty days; the *post-mortem* examination revealed great congestion of the lungs, amounting in some cases to consolidation of portions of the organ, congestion of the liver, congestion and swelling of the spleen, great congestion and general disease of the cortical part of the kidney. From the blood of these animals, taken directly from the heart, cultivations were established in nutritive gelatine, and hereby the existence of the same species of micrococci was revealed; they possessed all those special characters distinguishing the cultivations of the micrococcus of the Hendon cows and of the human scarlatina.

In the third and concluding section of the work, cultivations of the micrococcus of two cases of human scarlatina were used for infecting calves; two calves were inoculated, and two were fed from each set of cultivations. All eight animals developed disease, both cutaneous and visceral, identical with that produced in the calves that had been last year infected with the micrococcus from the Hendon cows.

From the heart's blood of calves thus infected from human scarlatina the same micrococcus was recovered by cultivation, possessing all the characters shown by the cultures of the micrococcus of the Hendon cows and of the cases of human scarlatina.

It must be evident from these observations that the danger of scarlatinal infection from the disease in the cow is real, and that toward the study and careful supervision of this cow disease all efforts ought to be directed in order to check the spread of scarlet fever in man. It is also obvious that in the agricultural interest investigations of this cow disease are greatly called for.

* Abstract of a paper lately read before the Royal Society.

CATARRH OF THE ANTRUM.

In cases of catarrh of the antrum, Dr. Schiffers, of Liege, instead of extracting the second molar, gains access to the cavity through the opening in the middle meatus of the nose. Through this he inserts a director, and with the help of a curved probe-pointed bistoury he opens up a passage for the free exit of the confined secretion. By the use of cocaine the patent suffers but little during the operation. Dr. Schiffers points out that catarrh of the antrum is frequently overlooked and mistaken for an affection of the nasal mucous membrane. When an abundant fetid discharge runs from the nose, especially when it is intermittent, the existence of disease of the antrum should be suspected, and a careful search made, with the help of the nasal speculum and a good light, for the welling up of the secretion through the foramen in the middle meatus.—*Lancet.*

THE "BLEEDING" OF PLANTS.

Herr C. Kraus (*Forschungen aus dem Gebiete der Agricultur-Physik*, 1887) has examined the phenomenon of "bleeding" in a number of plants, both woody and herbaceous. He finds it to be invariably the case that when the plant is still attached to the soil by its roots the sap that first exudes from the wound is acid, while that which flows out later is either neutral or slightly alkaline; and the same he found to be the case also with the cut shoots of the vine. The exuding sap is derived partly from the vessels and tracheids of the wood, partly from the tissue immediately adjacent to the wound. A larger amount of bleeding takes place as a rule from younger than from older plants.

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